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#245 OCTOBER 2025

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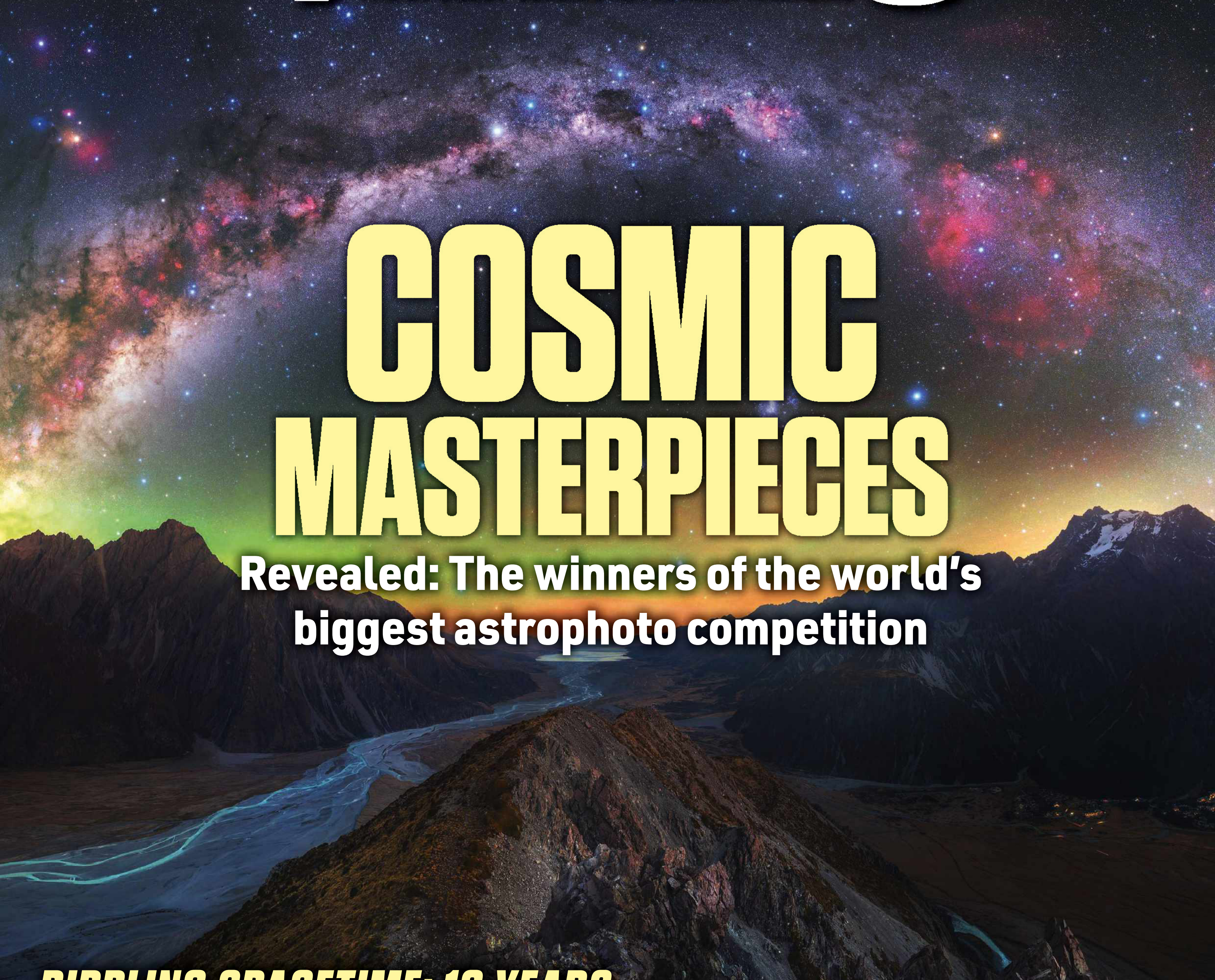

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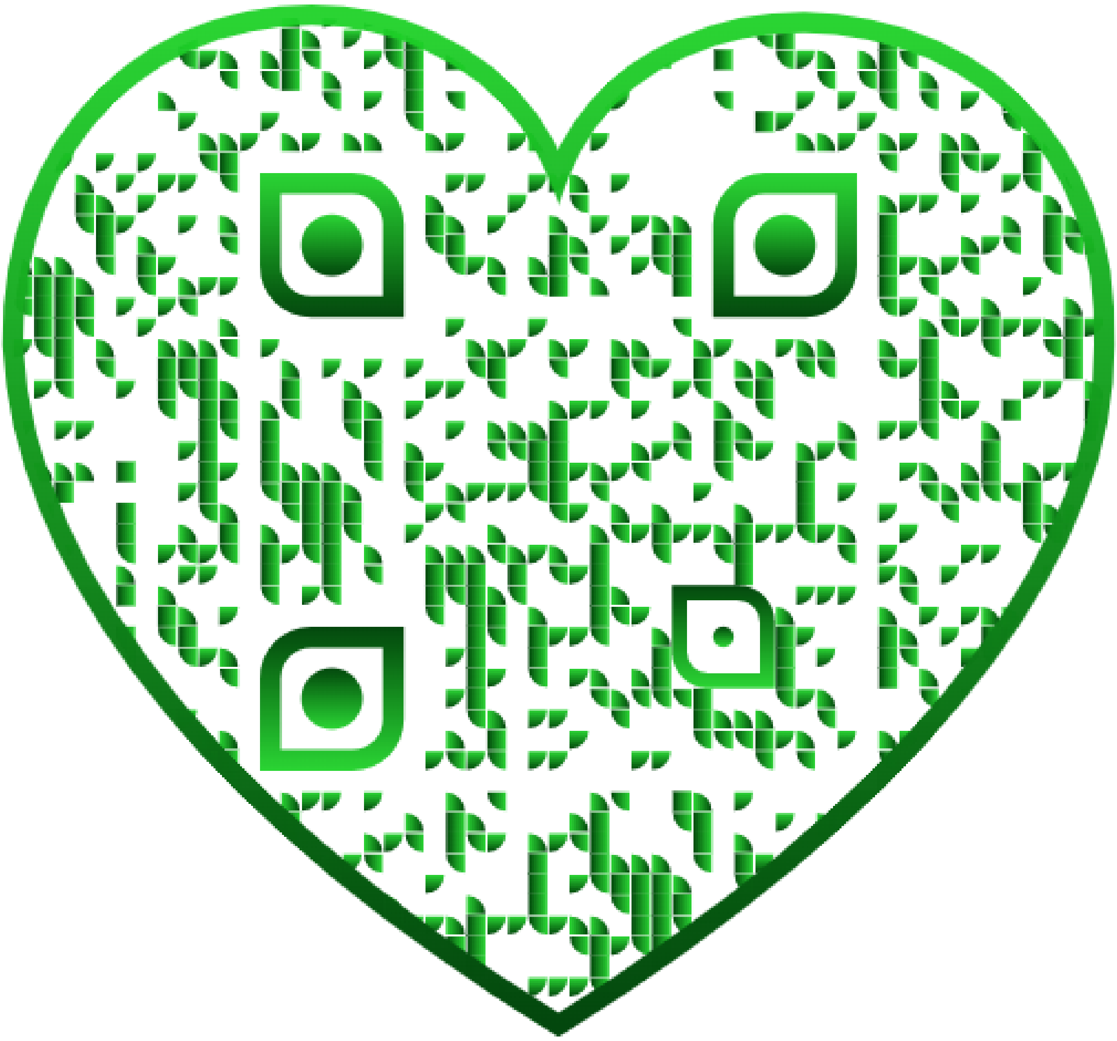

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Welcome

From 6,000 entries to 11 jaw-droppers…

The awe-inspiring photograph on this month's cover – 'The Ridge' by amateur astrophotographer Tom Rae – was taken in Aoraki/ Mount Cook National Park, New Zealand. It's the worthy winner of the Skyscapes category in this year's Astronomy Photographer of the Year competition, and one of the 11 stunning images featured in our winners' gallery this issue. Turn to **page 34** to see them all, including the overall winning image, selected from nearly 6,000 entries submitted from across the globe.

One region of the world that's graced with skyscapes as dramatic as Aoraki is Chile's Atacama Desert. Nestled between a coastal mountain range and the Andes, its high altitude and lack of light pollution make for some of the clearest, darkest skies on Earth – it's why many of the world's professional telescopes are based there. Travel writer Becca Marsh explored the Atacama for us this issue. On **page 60**, she shares how the dramatic beauty of its night skies moved her, along with tips on the best locations to visit, including a fascinating tour of the Very Large Telescope.

We turn to images of a different kind on **page 28**, as we celebrate the 50th anniversary of the first photo sent from the surface of another planet. Giles Sparrow marks the milestone with the remarkable stories behind seven images that revealed the surfaces of other Solar System bodies for the very first time.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 21 October.

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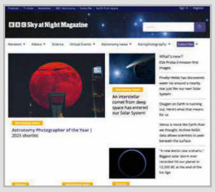
Sky at Night – lots of ways to enjoy the night sky...

The Sky at Night

Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18



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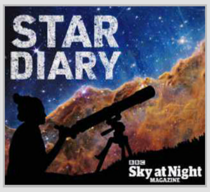
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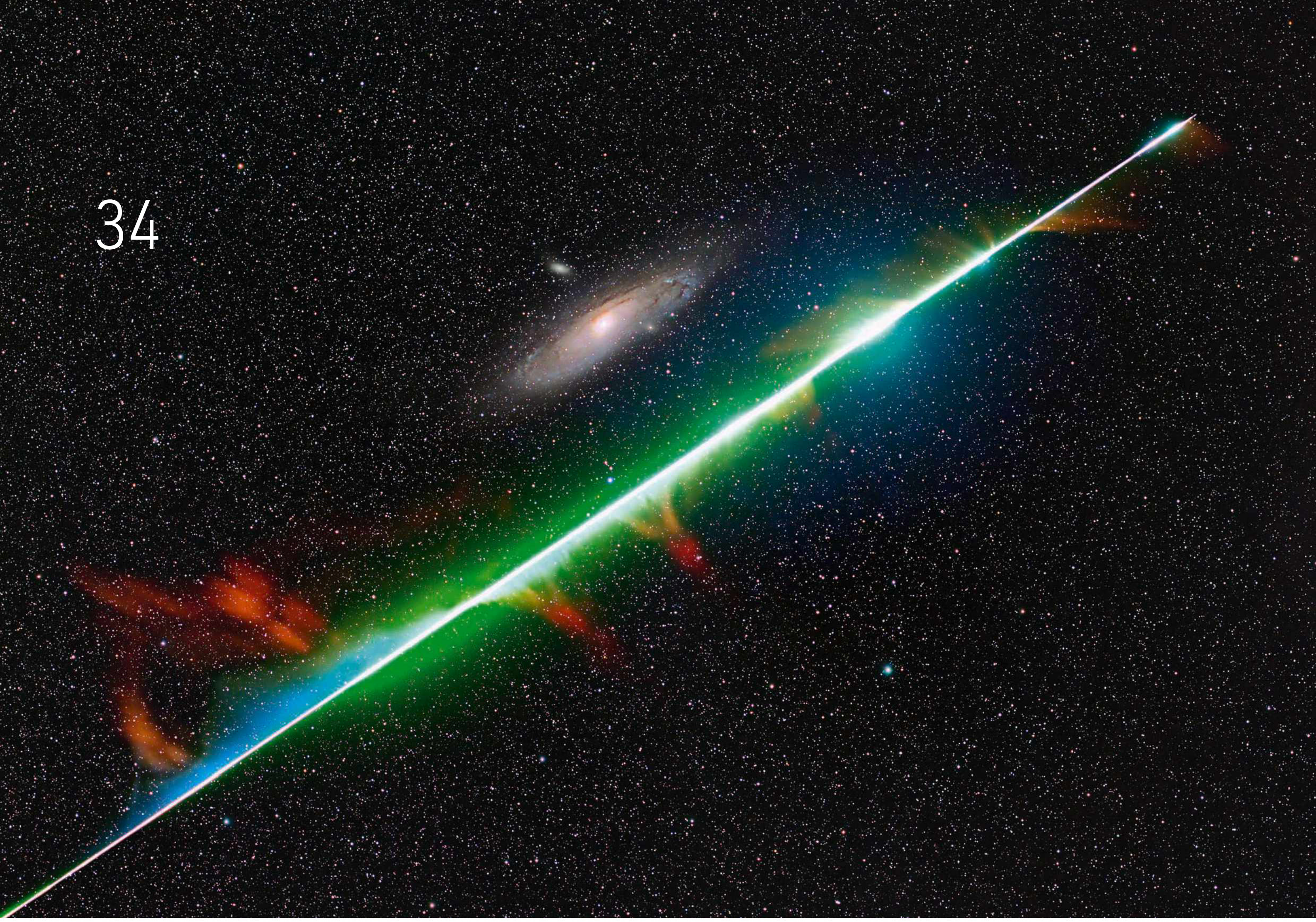

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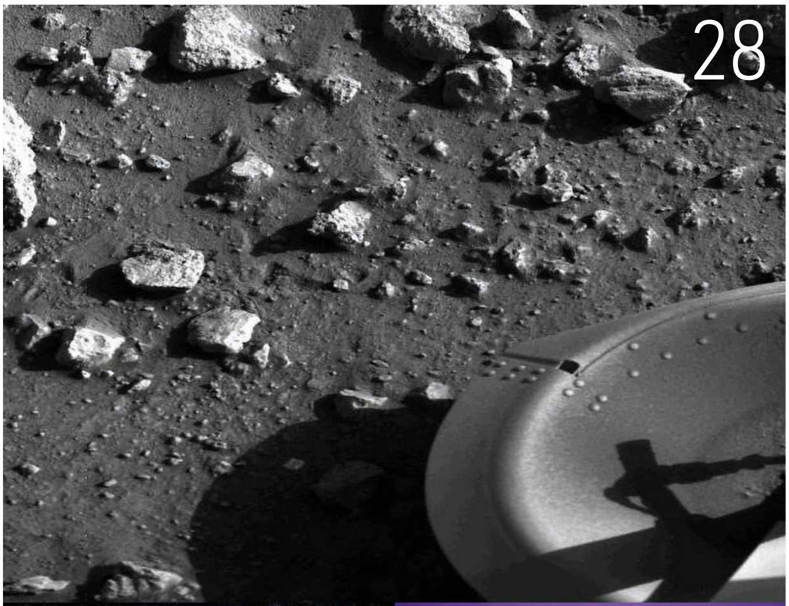
New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**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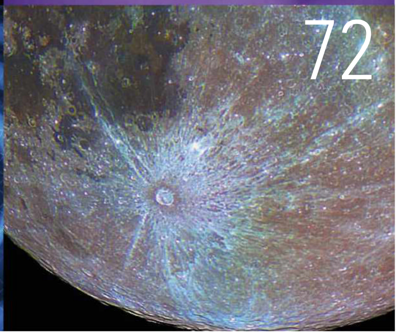
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This month's contributors

Giles Sparrow

Astronomy author

"It's 50 years since Venera 9 returned the first photos from the surface of Venus – but it's just one example of how we overcame engineering challenges to transform our view of the Solar System." **Find out how it was done on page 28**

Becca Marsh

Travel writer

"I spent three weeks traversing the rugged terrain of the Atacama Desert and experienced some of the world's clearest night skies." **Read about Becca's dark-sky adventures in the Atacama on page 66**

Charlotte Daniels

Reviews editor

"With three consecutive supermoons starting this month, I enjoyed practising my moonrise sequence capture, ready for the Harvest Moon!" **See Charlotte's guide to capturing a great moonrise sequence on page 74**

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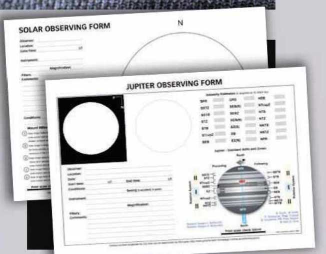
OCTOBER HIGHLIGHTS

Can YOU help find exploding stars?

Astronomer Tom Killestein reveals why he wants the public to help him find more stellar explosions.

Your best images of the Universe

Our extended gallery featuring the best astro images sent to us by *BBC Sky at Night Magazine* readers.



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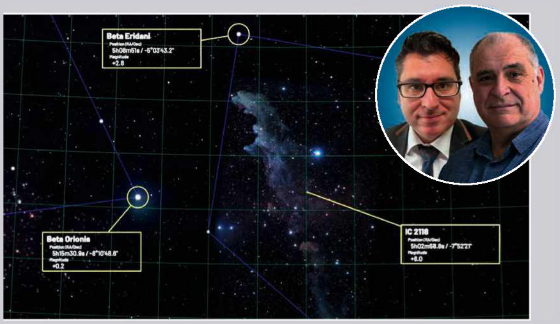


Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

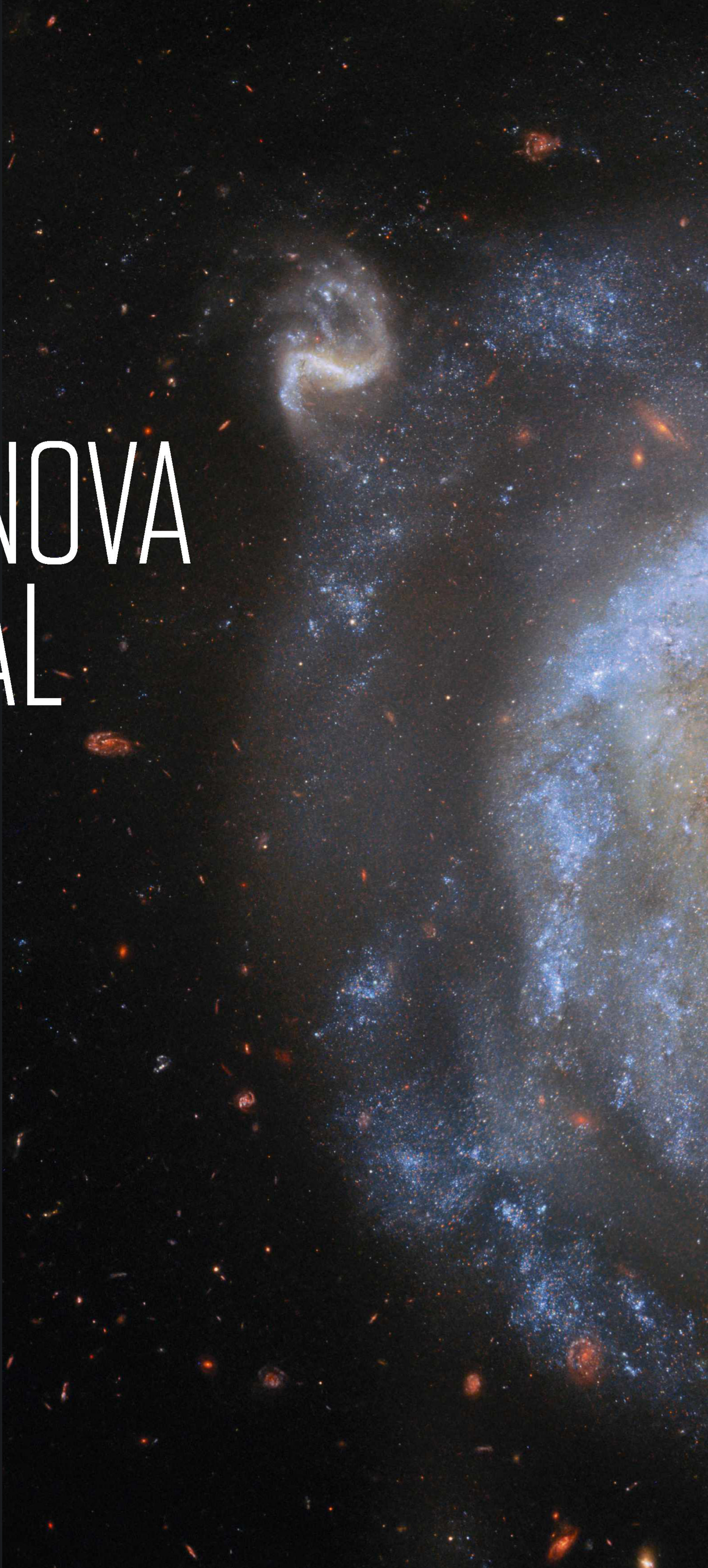
SUPERNOVA CENTRAL

Hubble revisits a spiral galaxy that's witnessed two supernovae in recent years

HUBBLE SPACE TELESCOPE,
28 JULY 2025

Spiral galaxies are among the most common in the Universe, making up around 60–70 per cent of all galaxies. One, NGC 1309 in the constellation of Eridanus, lies 100 million lightyears from Earth and has been imaged several times by the Hubble Space Telescope.

The reason? Though otherwise unremarkable, it's drawn attention for hosting not one but two supernovae since the turn of the millennium: the rather typical Type Ia SN 2002fk in 2002 and the rarer Type Iax SN 2012Z in 2012. Hubble showed that this second explosion left behind a partially destroyed white dwarf, a so-called 'zombie star'.



ESA, HUBBLE & NASA, L. GALBANY, S. JHA, K. NOLL, A. RIESS

FREE BONUS CONTENT

Explore a gallery of these and more stunning space images
www.skyatnightmagazine.com/bonus-content

△ Compare and contrast

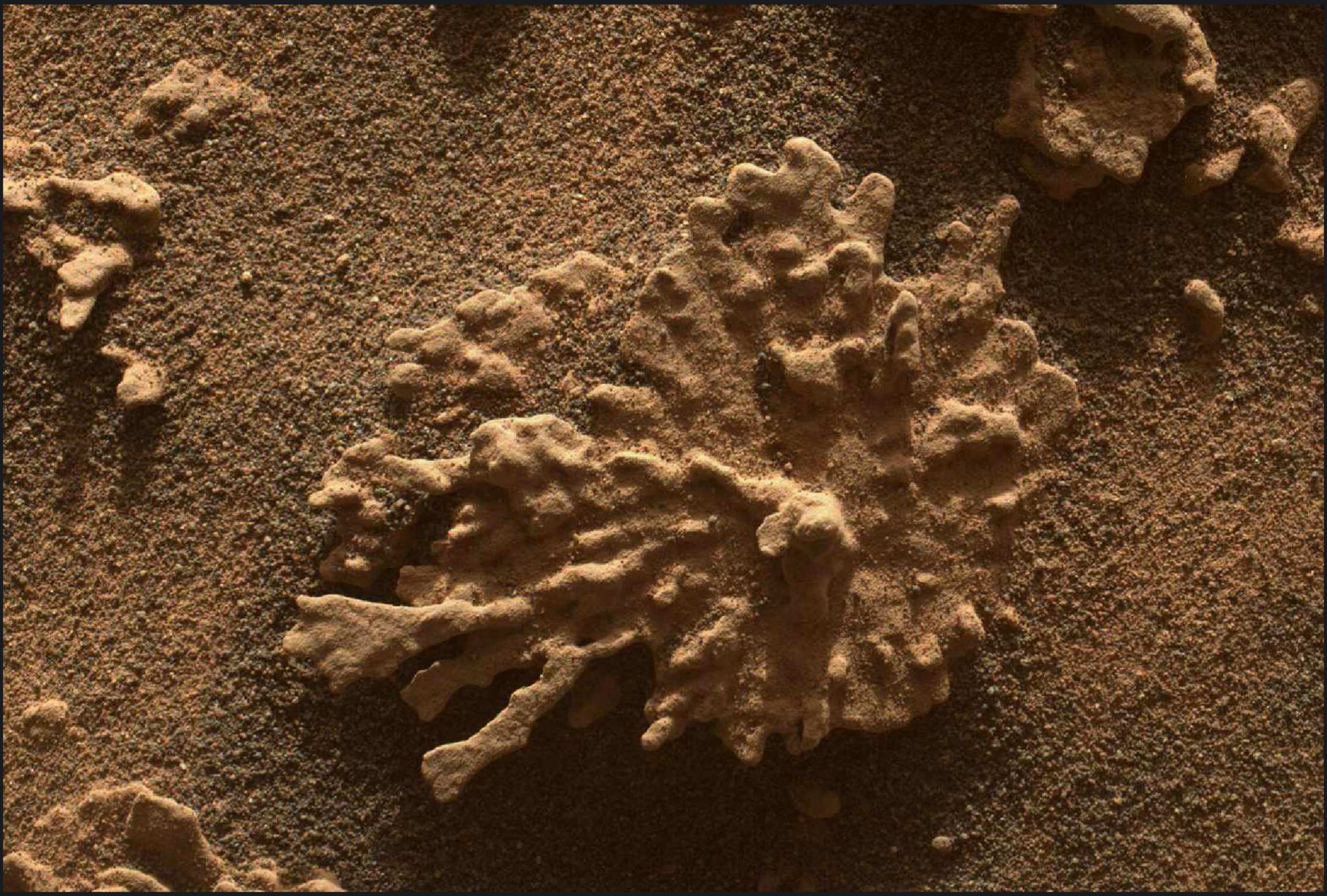
HUBBLE SPACE TELESCOPE, 14 JULY 2025

This is NGC 1786, a globular cluster in the Large Magellanic Cloud, a satellite galaxy of the Milky Way. It's been imaged by Hubble as part of a study comparing old clusters in nearby dwarf galaxies to clusters in our own Milky Way, helping astronomers learn more about how these star-packed relics form and evolve.

▽ Curious coral

CURIOSITY MARS ROVER, 4 AUGUST 2025

This isn't actually a piece of coral – it's a rock formed from minerals deposited by liquid water that once flowed into rock cracks on the Martian surface. Over millions, if not billions, of years, the water disappeared and the surrounding material was eroded by wind, leaving behind the intricate structure seen here.



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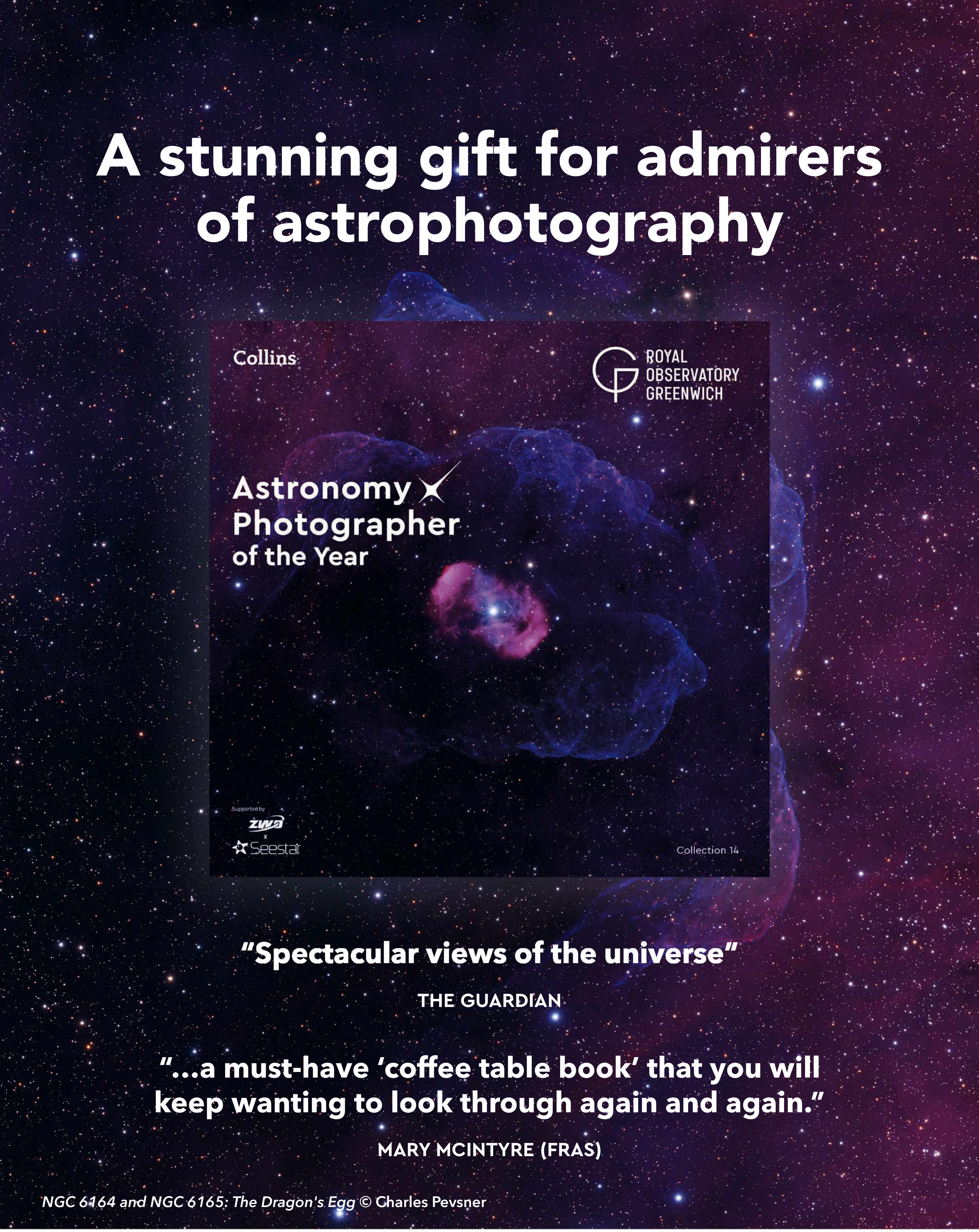
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MARY MCINTYRE (FRAS)

NGC 6164 and NGC 6165: The Dragon's Egg © Charles Pevsner

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The latest astronomy and space news, written by Jamie Middleton

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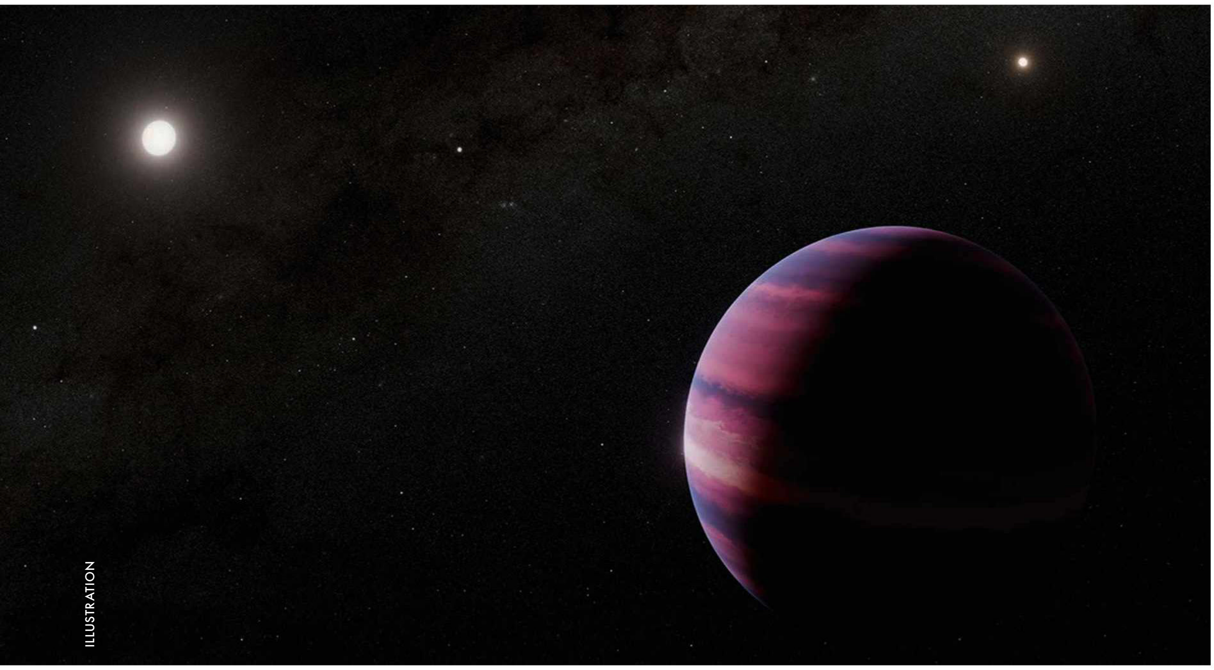


▲ **JWST has provided strong evidence of a gas giant orbiting a Sun-like star just four lightyears away**

Possible planet found at Alpha Centauri A

If true, it would be the closest exoplanet ever found in a habitable zone

The number of planets discovered orbiting other stars stands at over 6,000 and counting, but that's just the confirmed ones. Many more candidate exoplanets are awaiting verification, some of which are so promising that they warrant further investigation.

One of these tantalising prospects is located in our nearest star system, Alpha Centauri, and – if confirmed – will be the closest exoplanet to Earth to also fall within its star's habitable zone. At just four lightyears away from us, the planetary candidate is thought to be orbiting Alpha Centauri A, a star which is around the same size and age as our Sun.

Before we get too excited, while it's located in an orbit that could potentially support life – that is, one where liquid water could exist – the planet is thought to be a gas giant like Saturn. This means it is unlikely to host life as we know it. However, it may well have moons that are more habitable.

If it is there, this planet has been playing hide and seek with the astronomers trying to observe it. With an initial detection back in August 2024, subsequent observations in February and April this year did not reveal any similar objects. "We are faced with the case of a disappearing planet!", says PhD student Aniket Sanghi of Caltech, co-author of research papers about the candidate planet. "To investigate this mystery, we used computer models to simulate millions of potential orbits, incorporating the knowledge gained when we saw the planet, as well as when we did not. We found that in half of the possible orbits simulated, the planet moved too close to the star and wouldn't have been visible to JWST in both February and April 2025."

If confirmed by further observations, it could transform the future of exoplanet science. Future studies will use spectral imaging to try to ascertain the planet's composition and how habitable any orbiting moons could be.

"With this system being so close to us, any exoplanets found would offer our best opportunity to collect data on planetary systems other than our own," says co-author Charles Beichman, senior scientist at NASA's Jet Propulsion Laboratory. "Yet, these are incredibly challenging observations to make, even with the world's most powerful space telescope, because these stars are so bright, close, and move across the sky quickly."

www.webbtelescope.org

Comment

by Chris Lintott

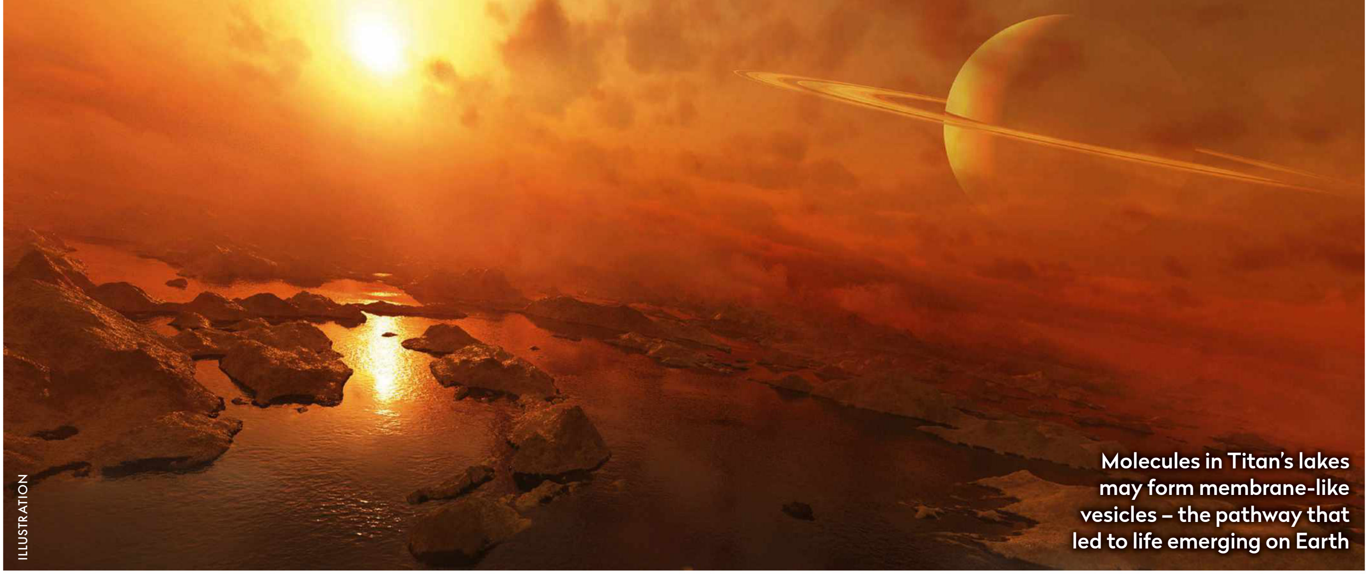
The discovery of a planet around one of our nearest stars is tantalising. We immediately want to study them in detail. Will we eventually visit this newfound world?

Interstellar travel seems as far off as ever, but scientists are working on audacious new missions to let us see these worlds. The plan is to put a space telescope in the outer reaches of our Solar System. Using the Sun as a gravitational lens, it could obtain images showing features as small as a few tens of kilometres across.

The effect would be as dramatic as the first exploration of the Solar System by robotic probes, turning what today is – charitably – at most an exciting blob into an actual world. What a sight that would be!

Chris Lintott co-presents *The Sky at Night*

NASA, ESA, CSA, STSCI, R. HURT (CALTECH, IPAC) | STEVEN HOBBS, STOCKTREK IMAGES, GETTY | IMPERIAL COLLEGE LONDON



Molecules in Titan's lakes may form membrane-like vesicles – the pathway that led to life emerging on Earth

Titan's lakes could form protocells

Study shows conditions are right to create vesicles, key structures in the origin of life

For cellular life to exist, it must separate itself from its surrounding environment by forming a membrane – a barrier that maintains the right internal conditions for life, despite external changes. NASA research now suggests the hydrocarbon lakes on Saturn's moon Titan contain the complex organic chemistry needed to form such protocells – primitive, cell-like structures that could represent an early step towards life.

Titan is the only place apart from Earth known to have liquid on its surface, with rivers, lakes and rain made not of water, but of hydrocarbons like methane and ethane. This moving liquid, combined with Titan's freezing atmosphere, creates ideal conditions for molecules called amphiphiles to form.

These molecules have two ends: one that interacts with liquid (hydrophilic) and one that repels it (hydrophobic). Amphiphiles can spontaneously arrange themselves into vesicles resembling a soap bubble, encapsulating a pocket of liquid on the inside. Vesicles are believed to be how complex life started here on Earth, making this a compelling avenue for investigating alternative pathways for the emergence of life that don't rely on water-based biochemistry.

"The existence of any vesicles on Titan would demonstrate an increase in order and complexity, which are conditions necessary for the origin of life," explains Conor Nixon of NASA's Goddard Space Flight Center. "We're excited about these new ideas, because they can open up new directions in Titan research and may change how we search for life on Titan in the future."

www.cambridge.org

First female Astronomer Royal appointed

Professor Michele Dougherty has led landmark space missions to Saturn and Jupiter

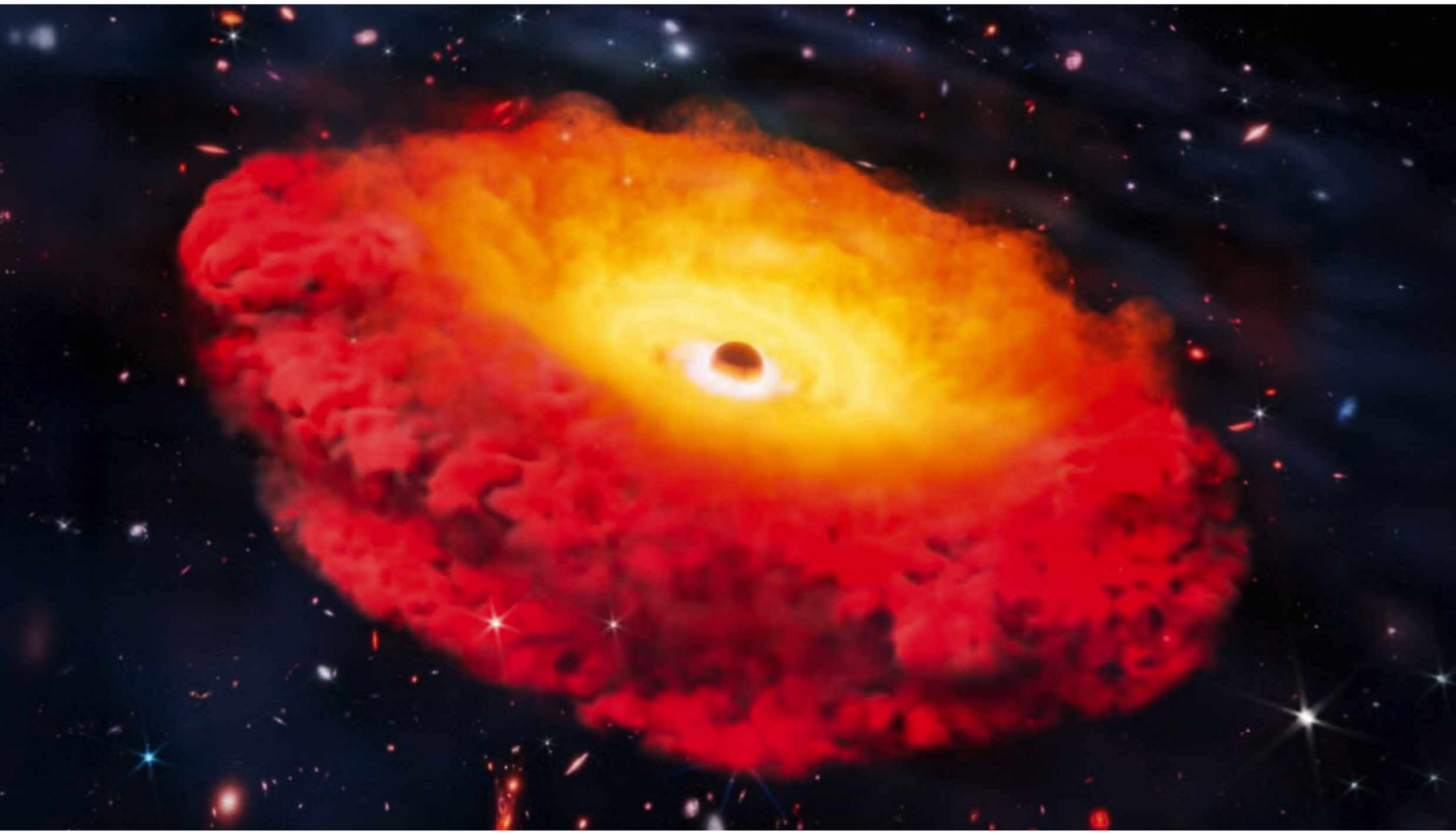
Professor Michele Dougherty has been appointed England's Astronomer Royal, following the retirement of her predecessor Lord Martin Rees. She is the first woman to be appointed since the role was established in 1675.

The Astronomer Royal is now a largely honorary position, serving as the official advisor to the British monarch in astronomical matters. When it was created 350 years ago, its primary purpose was to determine how to calculate longitude using the stars, an urgent endeavour to improve navigation at sea.

It's no surprise King Charles III chose Professor Dougherty for the role. She's internationally recognised for leading uncrewed space missions to Saturn and Jupiter, and for her contribution to the discovery of water on Saturn's moon Enceladus. Her expertise lies in designing instruments to measure magnetic fields in space, including aboard NASA's Cassini mission and ESA's JUICE spacecraft. She follows a long line of eminent Astronomers Royal, including John Flamsteed, the first to hold the post, Edmond Halley, Sir George Biddell Airy and Sir Frank Dyson.

Dougherty is the first woman to hold the title of Astronomer Royal in its 350-year history

"I am absolutely delighted to be taking on the important role of Astronomer Royal," says Professor Dougherty. "As a young child, I never thought I'd end up working on planetary spacecraft missions and science, so I can't quite believe I'm actually taking on this position. I look forward to engaging the general public in how exciting astronomy is, and how important it and its outcomes are to our everyday life." **www.ras.ac.uk**



▲ An artist's impression of CAPERS-LRD-z9, glowing red from gas enshrouding the colossal black hole, the most distant ever confirmed

ERIK ZUMALT, THE UNIVERSITY OF TEXAS AT AUSTIN | NASA, ESA, CSA, STSCI X 2

Earliest black hole discovered

The supermassive black hole dates from just 500 million years after the Big Bang

A supermassive black hole has been discovered that formed when the Universe was just 3 per cent of its current age – around 500 million years after the Big Bang, or 13.3 billion years ago. Found in the centre of a galaxy known as CAPERS-LRD-z9, it's the most distant black hole ever confirmed and a rare glimpse into the cosmic dawn.

The black hole was spotted by an international team of astronomers led by the Cosmic Frontier Center at the University of Texas at Austin, using data from the James Webb Space Telescope.

"When looking for black holes, this is about as far back as you can practically go," says Anthony Taylor, a postdoctoral researcher at the centre. "We're really pushing the boundaries of what current technology can detect."

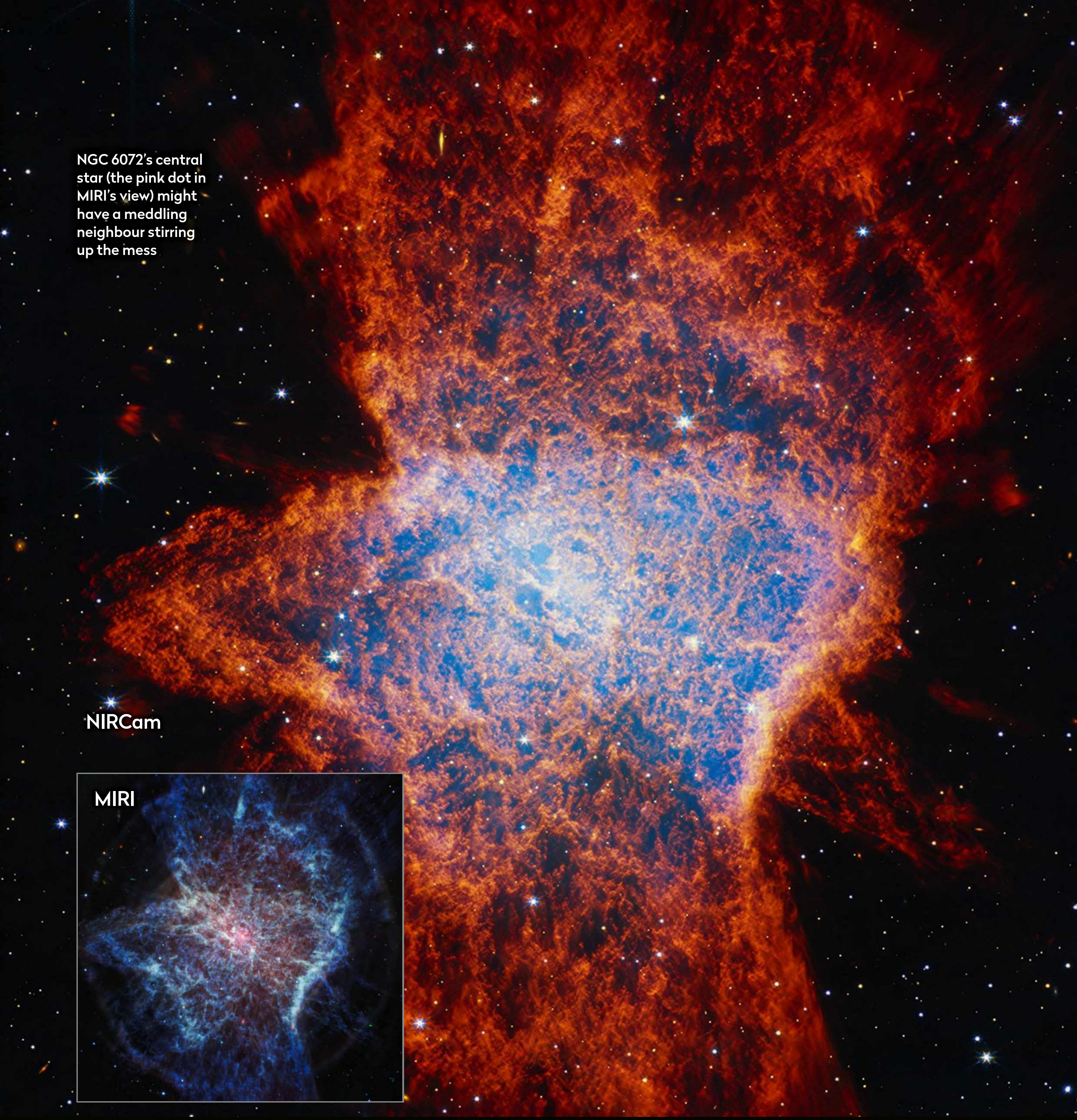
The team used spectroscopy to split the light from CAPERS-LRD-z9 into its component wavelengths and study the object's characteristics. This revealed a broad hydrogen emission line, a telltale sign of gas circling a black hole and falling into the gravity well in its centre. As the fast-moving gas is pulled into this singularity, the wavelength of its light is stretched to much redder wavelengths. As Taylor explains, "There aren't many other things that create this signature. And this galaxy has it!"

Not only that, but this black hole is a monster, estimated to be up to 300 million times the mass of our Sun, unusual for such an early epoch. Its host galaxy CAPERS-LRD-z9 belongs to a newly identifed class of galaxies know as little red dots, which are very compact, red and unexpectedly bright. These seem to have only been present in the first 1.5 billion years of the Universe and are unlike anything ever seen before.

"The discovery of little red dots was a major surprise from early JWST data, as they looked nothing like galaxies seen with the Hubble Space Telescope," explains Steven Finkelstein, a co-author on the study. "Now, we're in the process of figuring out what they're like and how they came to be."

The team hopes to gather higher-resolution JWST observations. "This is a good test object for us," says Taylor. "We haven't been able to study early black hole evolution until recently, and we're excited to see what we can learn from this unique object."

www.news.utexas.edu



NGC 6072's central star (the pink dot in MIRI's view) might have a meddling neighbour stirring up the mess

JWST decodes the chaos behind paint-splash nebula

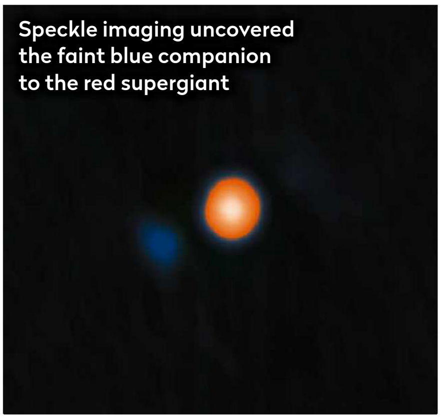
A companion star may be sculpting tangled NGC 6072, a rare multipolar planetary nebula

Planetary nebulae come in all shapes and sizes, but there's usually a degree of order to their structure. Most are circular, elliptical or bi-polar, and are caused by stars nearing the end of their life and spewing up to 80 per cent of their mass into space as a shell of gas and dust.

NGC 6072, in contrast, looks like a splash of paint on canvas. To help understand how this chaotic nebula was formed, astronomers used JWST's Near-Infrared Camera (NIRCam) and Mid-Infrared Instrument (MIRI) to study it in detail. Their observations revealed that NGC 6072 is multipolar. That's to say, there are several outflows of gas and dust coming out of its centre, rather than the more usual one or two. Astronomers now believe the nebula's messy but beautiful appearance is due to the presence of more than one star at its centre. Specifically, it's thought a companion star is carving rings through the streams of gas flowing from the older star's core, creating ripples much like those seen on a pond.
www.webbtelescope.org

Betelgeuse's companion star confirmed

Century-old mystery solved with direct detection of a binary to the famous variable star


Speckle imaging uncovered the faint blue companion to the red supergiant

Betelgeuse is the 10th-brightest star in the night sky, 700 times the size of our Sun, and has fascinated humans for millennia. Now, at last, a 100-year-old mystery has been put to rest with the discovery of what causes it to dim every six years: a binary companion.

The idea of a companion star was first proposed in 1908, based on early spectroscopic data. But Betelgeuse's intense brightness has made detecting anything nearby extremely difficult.

Astronomers at the NASA Ames Research Center overcame this difficulty by using a technique called speckle imaging. Using the Gemini North telescope, they took a large number of very short exposures to filter out the blurring effect caused by Earth's atmosphere. The result was the detection of a small, dim binary companion star spinning around Betelgeuse in a very tight orbit. They were also able to determine that the star is six magnitudes fainter than Betelgeuse and has an estimated mass of around 1.5 times that of our Sun.

"Gemini North's ability to obtain high angular resolutions and sharp contrasts allowed the companion of Betelgeuse to be directly detected," says Steve Howell, senior research scientist at Ames. "The papers that predicted Betelgeuse's companion believed that no one would likely ever be able to image it."

The researchers have also proposed a fitting name for this faint binary twin: as Betelgeuse gets its name from Arabic, meaning 'the hand of al-Jawza', a female figure from Arabian legend, they suggested naming the orbiting star 'Siwarha', which means 'her bracelet'.

"I hope our discovery excites other astrophysicists about the robust power of ground-based telescopes and speckle imagers – a key to opening new observational windows," says Howell. "This can help unlock the great mysteries in our Universe."

www.gemini.edu

UK Space Agency to be streamlined

It will join the Department for Science, Innovation and Technology by April 2026

It's thought the agency will remain headquartered at Harwell in Didcot

It's been announced that by April next year, the UK Space Agency (UKSA) will be absorbed into the UK government's Department for Science, Innovation and Technology, in a move to cut duplication, reduce bureaucracy and strengthen public accountability.

The agency will keep its name and brand, and will be staffed by experts from both organisations. There will also be no immediate changes to the grants or contracts already in place.

Space Minister Sir Chris Bryant explains: "Bringing things in house means we can bring much greater integration and focus to everything we are doing, while maintaining the scientific expertise and the immense ambition of the sector."

UK Space Agency CEO Dr Paul Bate adds: "Having a single unit with a golden thread through strategy, policy and delivery will make it easier to translate the nation's space goals into reality."

Officials say the change won't be a blow for the UK's space industry, which contributed £18.6 billion to the UK economy in 2023. UKSA has notched up many successes since its founding in 2010, including sending Tim Peake to the ISS and developing domestic capabilities to launch small satellites from Scotland.

"It's important that the new body engages with industry and maintains a close dialogue throughout the merger to ensure the UK space sector remains at the top table internationally," Martin Bransby, Head of Navigation at Telespazio UK, told technology trade association TechUK.

www.gov.uk/uksa

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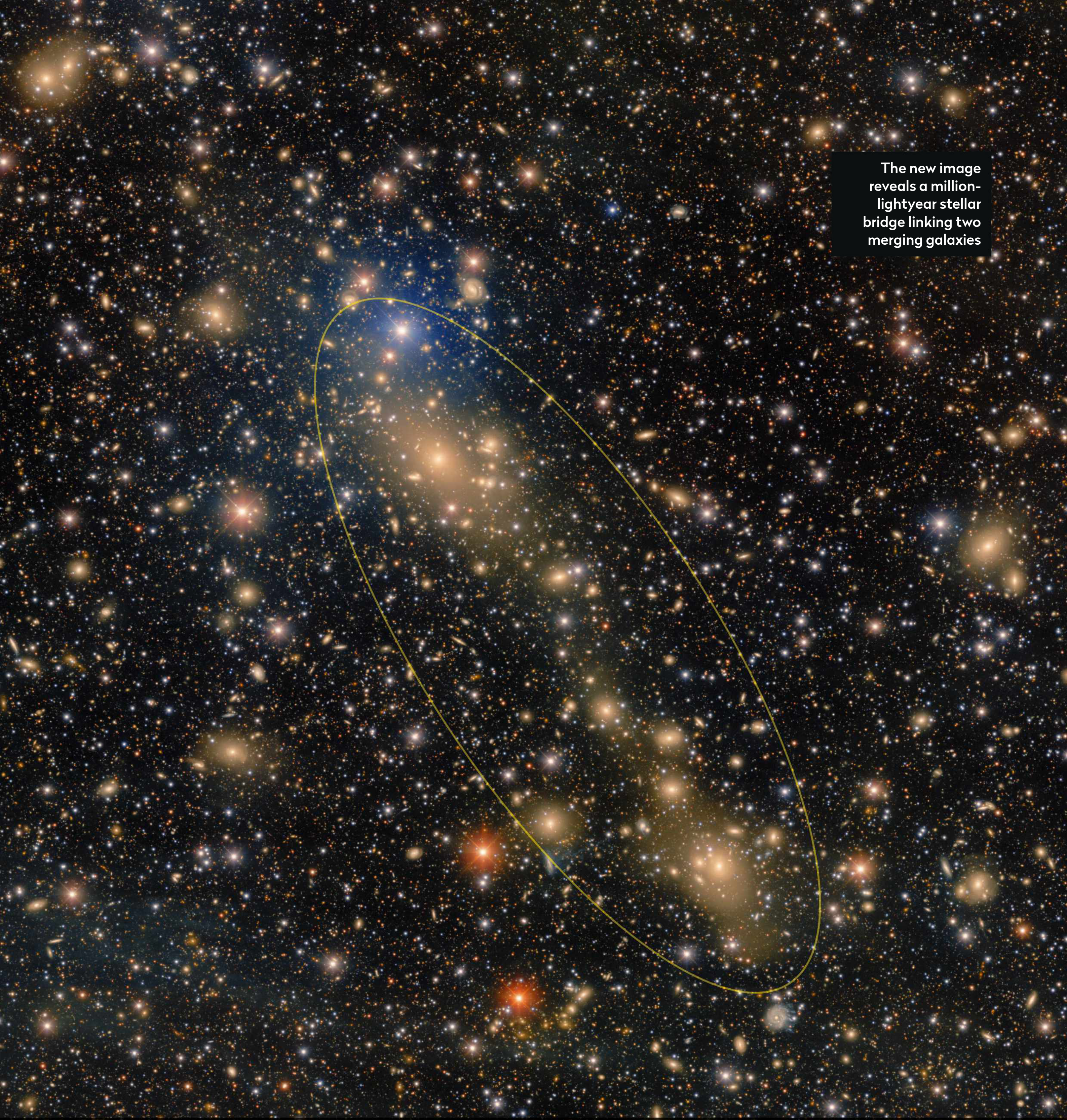


The new image reveals a million-lightyear stellar bridge linking two merging galaxies

Bridge of stray stars revealed

Dark Energy Camera image of galaxy cluster Abell 3667 brings cosmic history into focus

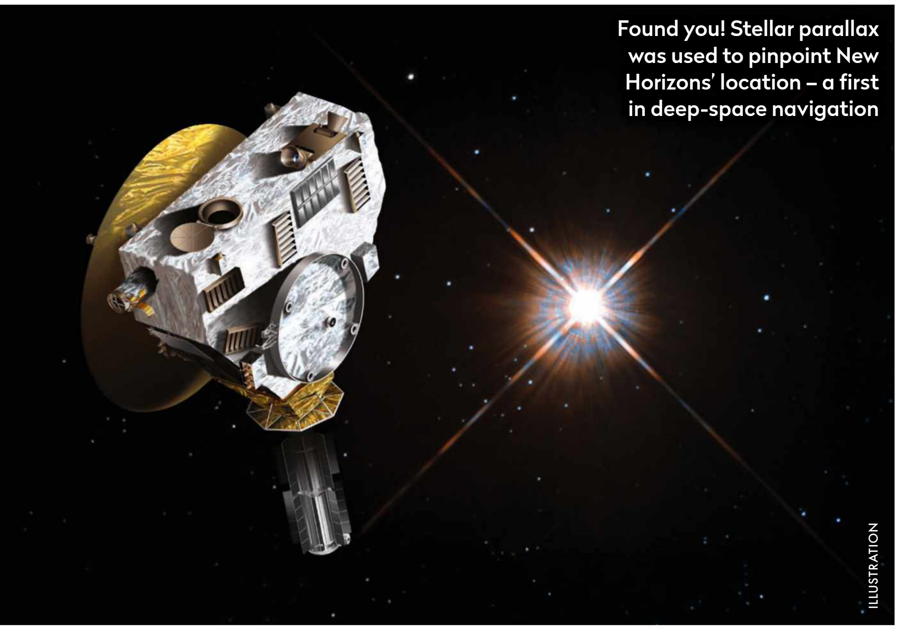
Galaxy clusters are among the largest structures in the Universe, created when hundreds or thousands of galaxies become gravitationally bound over billions of years.

Now, 28 hours of observations using the 570-megapixel Dark Energy Camera have produced the deepest image yet of galaxy cluster Abell 3667. It reveals a ghostly, million-lightyear-long bridge of lone stars connecting two small galaxies within the cluster – direct evidence that these galaxies are actively merging, pulling each other apart as they do so.

"This is the first time a feature of this scale and size has been found in a local galaxy cluster," says Anthony Englert, lead author of the new research. "We knew that it was possible for a bridge like this to form between two galaxies, but it hadn't been documented anywhere before now. It was a huge surprise that we were able to image such a faint feature." **www.noirlab.edu**

Our experts examine the hottest new research

CUTTING EDGE



Found you! Stellar parallax was used to pinpoint New Horizons' location – a first in deep-space navigation

How to find a speck in space

New Horizons proves stellar parallax can locate a probe in the vastness, using the light of just two stars

New Horizons was the first mission sent to explore Pluto, conducting a fly-by in July 2015. It was then redirected for a close pass of a much smaller Kuiper Belt object, Arrokoth, in January 2019. Today, it's over 61 AU away – almost twice as distant as Pluto – and racing from the Sun at around 50,000km/h (31,000mph), meaning that it covers the equivalent of the Earth–Sun distance every four months.

It's the fifth robotic spacecraft that we humans have launched on an escape trajectory that will ultimately leave the Solar System altogether and enter interstellar space. Indeed, the craft is already so remote that nearby stars appear to shift in position when viewed from the spacecraft, compared to how we see them from Earth. This displacement in the apparent position of objects seen from two vantage points is known as parallax. You can create this effect for yourself with a simple experiment: hold a finger at arm's length and alternate closing each eye. The finger appears to jump back and forth against the more distant background, because each eye sees it from a slightly different angle.

Tod Lauer, at the NSF National Optical-Infrared Astronomy Research Laboratory in Tucson, Arizona, led a team of 53 co-authors from 46 institutions to demonstrate stellar parallax between New Horizons and Earth. They did this by coordinating the probe to photograph two nearby stars with images taken simultaneously from ground-based observatories.

The team commanded New Horizons' LORRI (Long Range Reconnaissance Imager) camera to photograph the nearest star to the Solar System – Proxima Centauri, 4.25 lightyears away – on 22 April 2020. The timing coincided with new Moon conditions, allowing for simultaneous observations using the 0.4-metre (1.3ft) telescope at Siding Spring, the Australian node of the Las Cumbres Observatory global network. The following day, LORRI imaged another nearby star – Wolf 359, 7.86 lightyears away – at the same time as the University of Louisville 0.6-metre (2ft) Manner Telescope at Mount Lemmon Observatory, near Tucson.

Seeing double

Proxima Centauri appears to shift the most between Earth's and New Horizons' viewpoints, with an observed parallax of 32.4 arcseconds (0.009°), whereas the more distant Wolf 359 has a parallax of about half as much, at 15.7 arcseconds (0.004°). With the shifts in just these two star positions, the researchers were able to calculate the 3D position in space of New Horizons using stellar parallax and the extremely accurate map of our galactic neighbourhood produced by the Gaia space telescope.

> ***"With the shifts in just two star positions, the researchers were able to calculate the 3D position in space of New Horizons"***

Lauer says this is the first time such a technique has been used to locate a spacecraft with respect to nearby stars, and their calculation of New Horizons' range of 46.9 AU was just 0.5 per cent off that determined precisely by tracking from NASA's Deep Space Network of radio dishes.

For centuries, humans have navigated the world by treating the stars as fixed points on the celestial sphere. What Lauer and his colleagues have demonstrated for the first time is navigation based on stellar parallax, as the stars themselves seem to shift over immense distances. And this technique will become enormously important as we come to sail the cosmic ocean on interstellar voyages.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading… *A Demonstration of Interstellar Navigation Using New Horizons* by Tod R Lauer, David H Munro et al.
Read it online at: arxiv.org/abs/2506.21666

NASA AND ESA, NASA, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY, SOUTHWEST RESEARCH INSTITUTE | MARK PATERNOSTRO, SCIENCE PHOTO LIBRARY, ALAMY

Why the Blaze star is keeping us waiting

New modelling reveals why famous nova T CrB hasn't blown – yet

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

Sometime in the next year or so, if predictions are to believed, you're going to be hearing a lot about a famous star. T Coronae Borealis, or T CrB for short, was the first well-observed nova, blossoming into sudden brilliance in 1866 and then again in 1946. These observations point to a period between eruptions of about 80 years, and so astronomers expect T CrB to brighten to maybe fourth magnitude around about now.

The mostly Italian authors of this month's research paper have been observing the star for the last few years, aiming to understand what happens as a new nova event approaches.

Like all recurrent novae, T CrB consists of a white dwarf star with a larger star – in this case a red giant – for a companion. It is what's known as a symbiotic binary, with material from the giant flowing onto the white dwarf. Once enough material builds up on the white dwarf's surface, thermonuclear reactions can start and we see T CrB brighten in the sky.

The star had long slumbered since the outburst in the 1940s, but its spectrum and brightness started to change in 2016. It brightened quickly and then slowly returned to normal over the course of nearly eight years.

Discy business

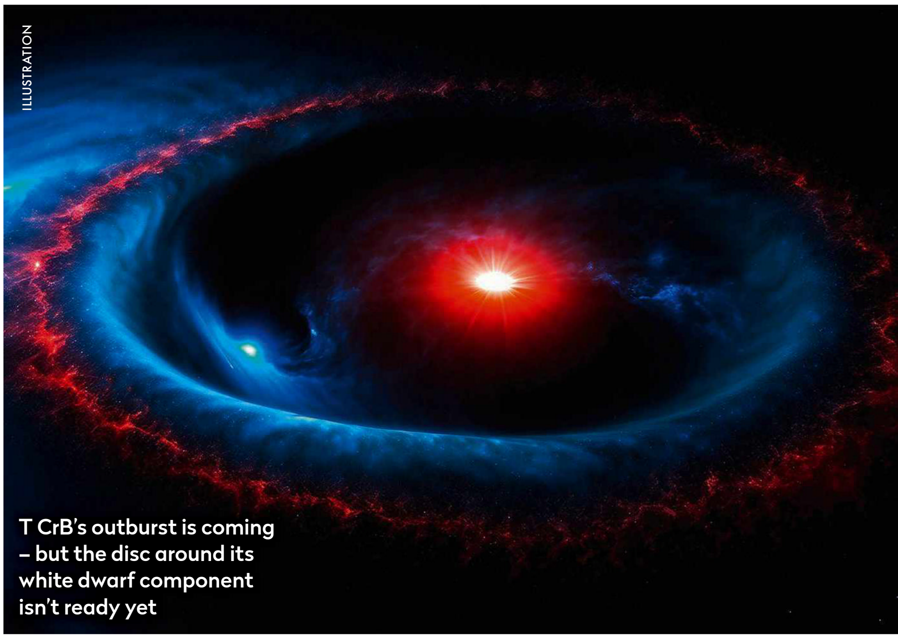
Spectral observations made during this period suggested that we were seeing more light from the accretion disc around the white dwarf – just what we'd expect as material began to accumulate. Careful modelling suggests the disc is massive, with a radius 58 times greater than the Sun's, and there is evidence for a bright hotspot where new, warm matter is hitting it. This hotspot didn't brighten as the star changed; this first phase, then, doesn't result from more material flowing from the giant, but must be due to changes in the disc itself as material builds up.

The star then suddenly dipped in brightness, not just in the optical but also in ultraviolet observations the team took with the Swift satellite. What seems to be happening is that the accretion disc reaches a maximum stable mass, and at that point 'flushes' material down towards the white dwarf. We see a fading star, but the conditions for an outburst, with matter building up on the white dwarf, are set.

> **"What seems to be happening is the accretion disc reaches a maximum stable mass, then 'flushes' material down towards the white dwarf"**

A comparison with historical observations – with the brightness of T CrB measured in painstaking fashion by researchers poring over digitised images of photographic plates from the 1940s – shows remarkable similarity right up until 2023, when the star recovered its former brightness. But while last time the main outburst occurred six months after the end of the dip, we're still waiting; it seems likely that less material has made it onto the white dwarf so far.

The research team calculate that about a tenth of an Earth mass has been transferred to the white dwarf to date: clearly not enough to trigger an outburst. Theoretical models disagree with each other, but all suggest we must be getting close. Material is flowing onto the accretion disc once more, and at some point, inevitably, it will reach that critical mass. When it does, telescopes around the world will once more point at what was once the most famous star of them all.



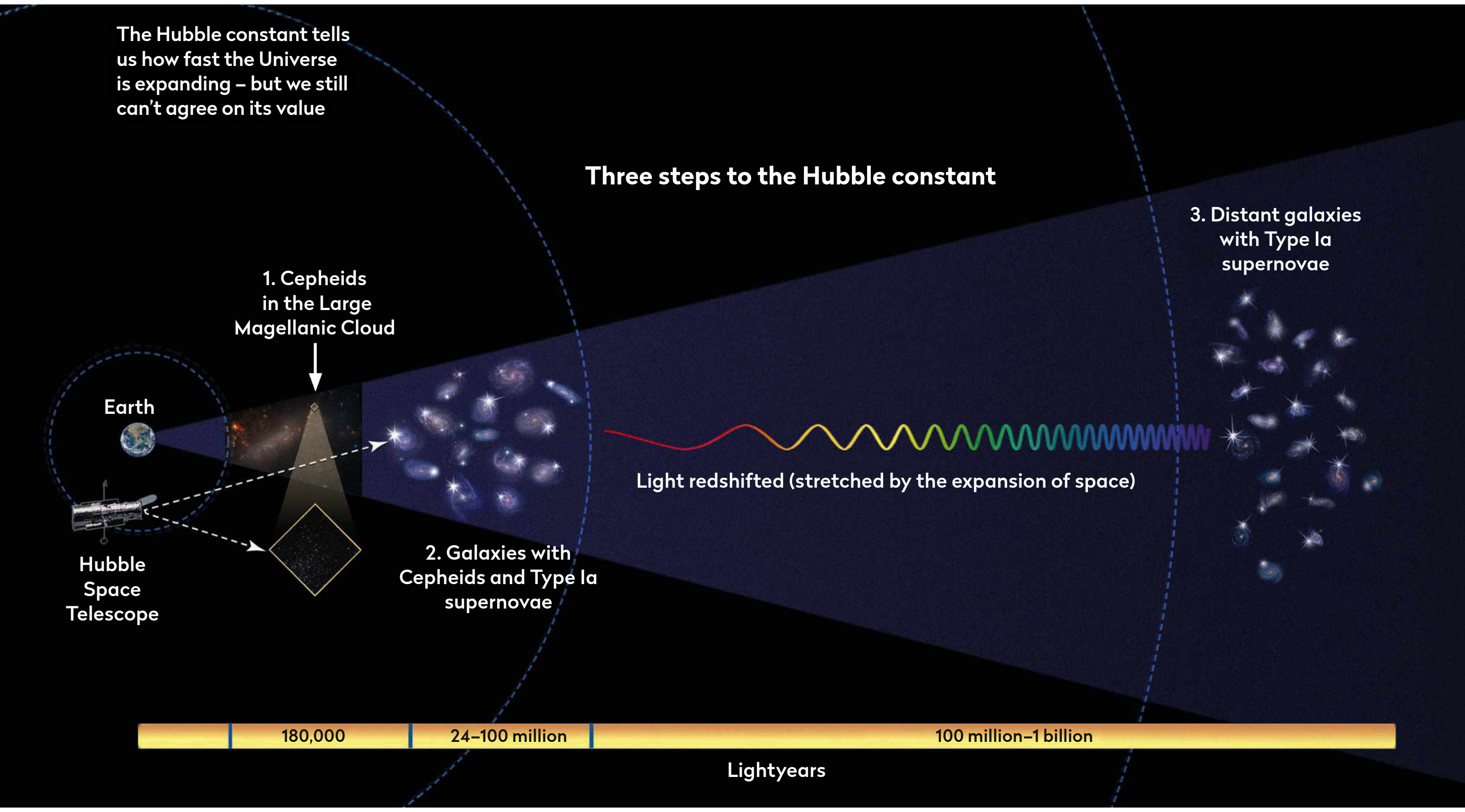
ILLUSTRATION

T CrB's outburst is coming – but the disc around its white dwarf component isn't ready yet

Chris Lintott was reading… *T CrB: Overview of the Accretion History, Roche-lobe Filling, Orbital Solution, and Radiative Modeling* by U Munari, F Walter et al. **Read it online at: arxiv.org/abs/2507.23323**

Behind the scenes of *The Sky at Night* TV show

INSIDE THE SKY AT NIGHT


The Hubble constant tells us how fast the Universe is expanding – but we still can't agree on its value
Three steps to the Hubble constant
1. Cepheids in the Large Magellanic Cloud
Earth
Hubble Space Telescope
2. Galaxies with Cepheids and Type Ia supernovae
Light redshifted (stretched by the expansion of space)
3. Distant galaxies with Type Ia supernovae
180,000
24–100 million
100 million–1 billion
Lightyears

NASA, ESA, AND A. FEILD (STSCI) | ESO | ESA, NASA

September's *Sky at Night* episode tackled the Hubble constant. **George Dransfield** considers how some of the cornerstones of science aren't as rock-solid as we thought

If there's one thing I love, it's a misnomer. Shooting stars, planetary nebulae, guinea pigs... none of them does what it says on the tin. Another great example is the term 'physical constant'. These are quantities that are so fundamental that they have the same value throughout the Universe, and have done since the dawn of time. Or so we think! Buckle up, readers: for one night only, I'm activating my long-dormant Physics Teacher Mode.

I have tremendously fond memories of my teaching days, and one particularly endearing thing my A-Level students did was show off to one another (and to me) how many physical constants they had memorised. I often pointed out that this was a legitimately pointless skill; after all, professional physicists have access to the internet. But still, they delighted in reciting the value of elementary charge, for instance, and groaned whenever I introduced yet another constant to add to the list.

George Dransfield is an exoplanet huntress at the University of Oxford and a presenter on *The Sky at Night*

Now, elementary charge – that is, the amount of charge on a proton – is a fundamental constant of nature. As in, every single proton in existence in the Universe, throughout all of time and space, has the exact same amount of charge. Forgive me if I nerd out about this point for a moment, but isn't it wild that we know this? I think so, at least.

September's episode of *The Sky at Night* deals with one of the biggest mysteries at the intersection of the fields of astronomy and cosmology: the value of the Hubble constant. This constant tells us the current rate of expansion of the Universe – but the word 'current' is doing a lot of heavy lifting here.

> **"It's a classic case of scientists naming a thing, then learning a metric tonne more about it"**

The Sky at Night wants your questions

For one special episode coming later this autumn, *The Sky at Night* is joining forces with the hit Radio 4 series *Curious Cases* to examine space mysteries sent in by you, the audience! If there's an intergalactic mystery you've always wanted an answer to, the team want to hear about it. Just email your question to **curiouscases@bbc.co.uk** and our expert presenters will get on the case.

Be in the audience

The Sky at Night's special episode with *Curious Cases* will be filmed in front of a live studio audience on 13 October 2025, in London. Audience tickets can be applied for at **www.bbc.co.uk/showsandtours** from early September.

The Hubble constant is not a proper fundamental constant of nature, as its value is thought to be the same throughout space but not time. Tune in to get the full scoop, but it's one of those classic cases of scientists naming a thing and then learning a metric tonne more about it. It's a bit like the word 'atom', originating from the Greek for 'indivisible' – another great misnomer as, famously, atoms contain all sorts of smaller bits inside. If you were a fan of *Friends*, that iconic 1990s sitcom, you may remember Phoebe teasing Ross about exactly this point.

Not so set in stone

However, when it comes to constants, even some of the ones we think really are bona fide fundamental constants no longer seem to be safe. For instance, there's the sexily named fine-structure constant, which tells us something rather important about the strength of the electromagnetic force.

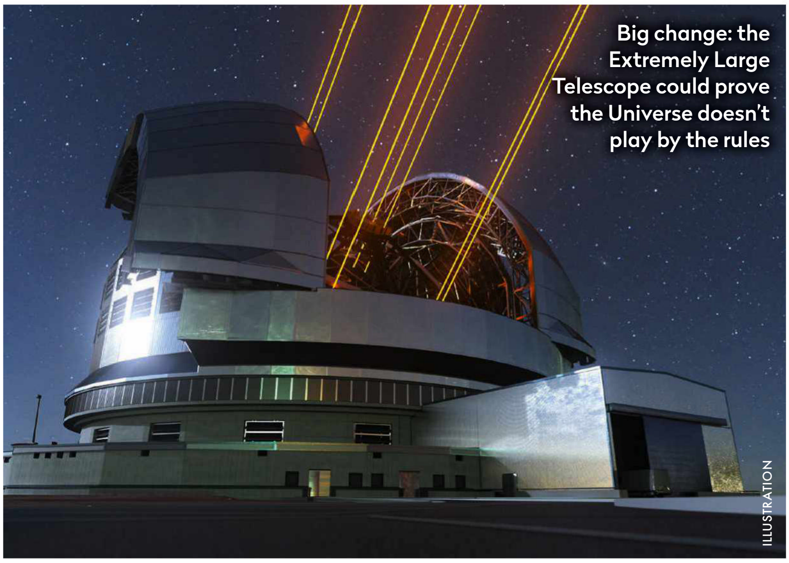
Its value is actually so important that it dictates whether or not elements like carbon can exist. As a carbon-based lifeform myself, I care deeply about the value of the fine-structure constant. But cutting-edge observations of quasars have recently indicated that this constant could be less constant than we previously thought.

Again, watch the episode of the show and you'll learn what's being done to resolve discrepancies with measurements of the Hubble constant, but there is other thrilling stuff in the works for many other (proper) constants. The upcoming ELT (Extremely Large Telescope – named with refreshing accuracy), currently being built on top of Cerro Armazones in northern Chile's Atacama Desert, will be used in part to search for spatial and/or temporal variations in fundamental constants. To put it simply, we may soon find out if the laws of physics are truly universal after all. This is… *Big*.

Honestly, cosmology isn't usually my jam. I find it ridiculously cool, but also constantly confusing (pun very much intended). But this bit really appeals to me. We could be on the precipice of a huge paradigm shift. We could, in fact, soon learn that not every single proton has the same charge. And if that happens, I'll be tempted to tell my former students that memorising constants was even more pointless than I thought. But really, I'll just be thrilled that they cared enough to try. Constantly.

How to watch

Catch the show on the BBC iPLAYER



Big change: the Extremely Large Telescope could prove the Universe doesn't play by the rules

ILLUSTRATION

The Sky at Night OCTOBER

Astronaut Rosemary Coogan is training to be one of the next Britons to visit the Space Station

Brits in Space

In this episode, *The Sky at Night* team find out how Britain is contributing to the space sector in the modern era, from engineering and innovation to the talented astronauts training to travel into space. We catch up with three British astronauts in training with the European Space Agency and find out what it takes to make the journey into Earth orbit.

BBC Four, **13 October**, 10pm (first repeat will be on BBC Four, **15 October**, 11.30pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information

Pure dodecadence?

The Twelve 660's profile is a minimalist 6.6mm. Accentuating its understated elegance is the absence of a date, second hand and luminescent paint. We re-engineered the bracelet. And re-sculpted the clasp, as the original would be taller than the new case. Yet the watch's distinctive DNA remains, in architectural elements like the dodecagon-sided bezel and lock ring. And glass-box sapphire crystals. The rear of which reveals the slim Sellita SW210 manual movement. Made slimmer still with a custom-designed, custom-made train bridge. In summary: same, different, less and more. Decadent design or perfected purity? You decide.

Do your research

Christopher
Ward

christopherward.com

Emails – Letters – Tweets – Instagram

INTERACTIVE

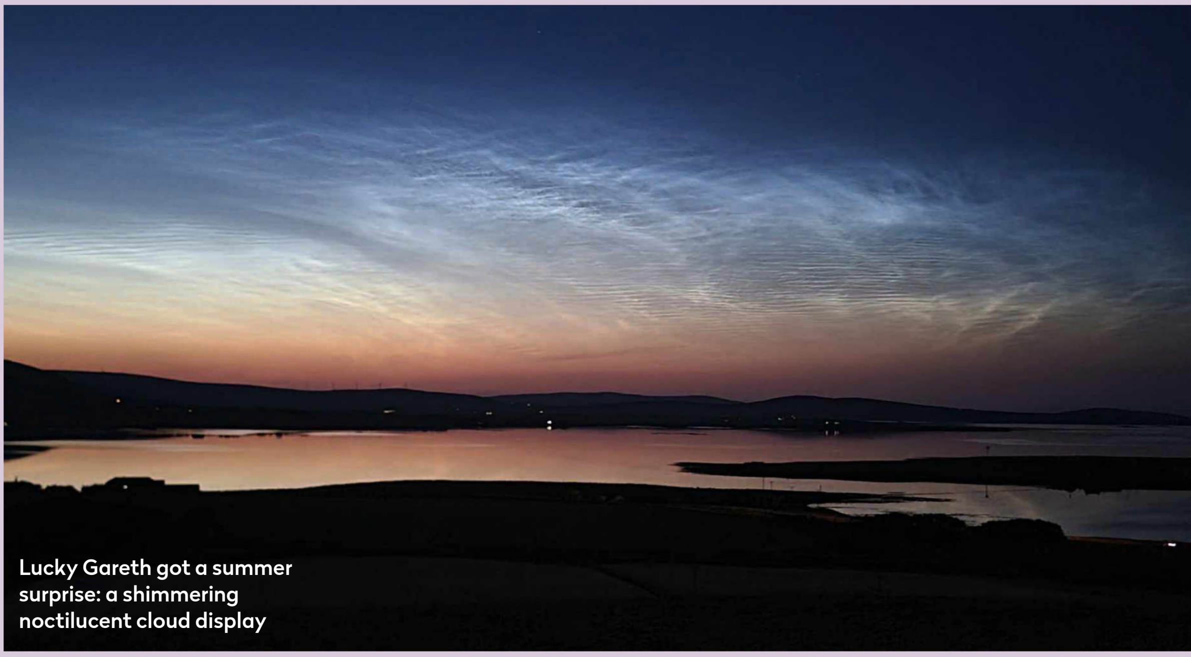
Email us at **inbox@skyatnightmagazine.com**

MESSAGE OF THE MONTH

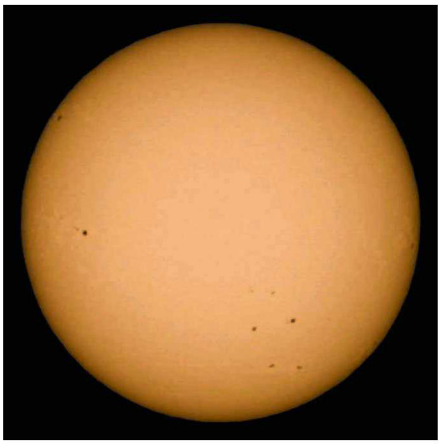
Orkney's twilight spectacle

I looked out of the window before bed while on holiday in Orkney in mid-August and was delighted to see my first-ever noctilucent cloud display! The reflections in the still waters of the Bay of Firth were an added bonus, and even capture some of the delicate ripples in the clouds.
Gareth Wilkes, via email

What a fortuitous glance out of the window, Gareth! That's a beautiful picture of an extensive display. Thanks for sharing. – *Ed.*



Lucky Gareth got a summer surprise: a shimmering noctilucent cloud display



▲ Solar success! Ed's birthday scope helped him finally nail some sunspots

Birthday treat

My amazing partner got me a Dwarf 3 smart scope for my birthday recently and for the first time ever I have managed to take a zoomed-in picture of the Sun, thanks to its ability to also take solar pictures. Not managed a clear night sky yet, however – but I live in hope!
Ed Gallagher, Troon, South Ayrshire, Scotland

East is west?

I'm sure the answer's obvious, but why do east and west seem to be reversed in your star charts?
Jane Davidson, via email

It's a common point of confusion, Jane, but there's a simple technique to getting your bearings with a printed star chart like the one we print on pages 50–51 each issue.

Unlike ground maps, which you hold with the direction you're facing at the top, you hold star charts with the direction you're facing at the bottom of the page, since they show the view overhead. Try facing north and holding our chart upside down. You'll find that east and west fall into place. – *Ed.* ▶

Instagram

slavias22 • 8 August
A night scene from the Hella area on the island of Kvaløya in Norway, where the moonlight gently illuminates the sharp mountain peaks. Above them stretches Orion, one of the most distinctive features of the winter sky. @bbcskyatnightmag

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EDITORIAL
Editor Chris Bramley
Content Editor Iain Todd
Commissioning Editor Jamie Middleton
Art Editor Steve Marsh
Senior Production Editor Jess Wilder
Reviews Editor Charlotte Daniels

CONTRIBUTORS
Anita Chandran, Lewis Dartnell, Glenn Dawes, Russell Deeks, George Dransfield, Chris Grimmer, Alastair Gunn, Tim Jardine, Pete Lawrence, Chris Lintott, Becca Marsh, Chris North, Ivana Peranic, Giles Sparrow, Steve Tonkin, Emily Winterburn, James Witts

ADVERTISING SALES
Advertising Executive Andy Williams
+44 (0)117 300 8803, Andy.Williams@ourmedia.co.uk
Inserts Laurence Robertson +353 (0)87 690 2208

CONTENT OPERATIONS
Content Operations Director Sarah Powell
Content Operations Coordinator Zahira Choudhury
Head of Operations Jessica Mills
Ad Coordinator Charles Thurlow
Ad Designers Cee Pike, Andrew Hobson
Reprographics Chris Sutch

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Brand Lead Rob Brock
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CEO Andy Marshall

BBC STUDIOS, UK PUBLISHING
SVP Global Licensing Stephen Davies
Global Director, Magazines Mandy Thwaites
Content Manager Cameron McEwan
UK.Publishing@bbc.com; www.bbcstudios.com

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Asnath caught this beautiful shot of Venus and Jupiter's August liaison

Dawn delight

▶ Always a beautiful morning, waking up to the sight of Venus and Jupiter in South Africa. Here's a photo I took of the conjunction on 12 August.

Asnath Motlalepula, via email

Comet memories

Your recent article about comet Hyakutake ('Hale–Bopp gets all the glory, but not many remember another beautiful comet that graced our skies the year before', www.skyatnightmagazine.com) brings to mind when I had the gift of seeing Hale–Bopp in Manitoba, Canada.

A friend and I drove to Birds Hill National Park and, in complete darkness, witnessed a wonder of space. The tail was stretched across the sky. The stillness of the sight made us both realise how small we were as a planet against the backdrop of space. Even though the comet was moving at almost 158,000mph, it hung in the sky for a week or so.

I was 44 years old; I'm now 72, and my friend and I were speaking of it last week, as we have periodically over the years. A sight, an event, truly amazing, and we both can easily go back to that precious time in an instant.

B Wimmer, Winnipeg, Manitoba, Canada

Tweet

SkyWatcherDave
@SkyWatch07 • 18 August

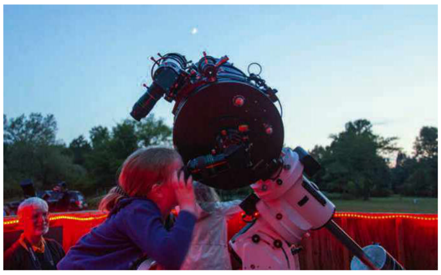
Fly me to the Moon... Two birds fly in front of the Moon, Co Clare, Ireland @BBCStargazing @skyatnightmag

SOCIETY IN FOCUS

Founded in 1936 by Leonard James Ashby, **Kalamazoo Astronomical Society** is Michigan's oldest and largest astronomy club, boasting over 400 members.

We hold meetings on the first Friday of the month, featuring guest speakers from surrounding colleges and universities. Notable speakers have included J Kelly Beatty, Alan Dyer, Fred Espenak and Alex Filippenko. Members share their latest brainstorming every June during Gadget Night and their best images as part of Astrophotography Night every October. These long-standing KAS traditions date back over 50 years.

From April to October, we share the night sky with the public at the Kalamazoo Nature Center. We set up around Owl Observatory, which has a 16-inch Schmidt–Cassegrain and a 4-inch refractor. We also own a remote telescope at Arizona Sky Village, where there's also a 20-inch PlaneWave and a 4-inch Takahashi. From November to February, we share live images from these telescopes with viewers around the world.



RICHARD BELL

▲ A young visitor looking through KAS's 16-inch telescope at Owl Observatory

2026 marks our 90th anniversary. Plans include a variety of special guests and the return of our renowned Introduction to Amateur Astronomy lecture series. Visit our award-winning website for info on how to attend in person or online.

Richard Bell, president

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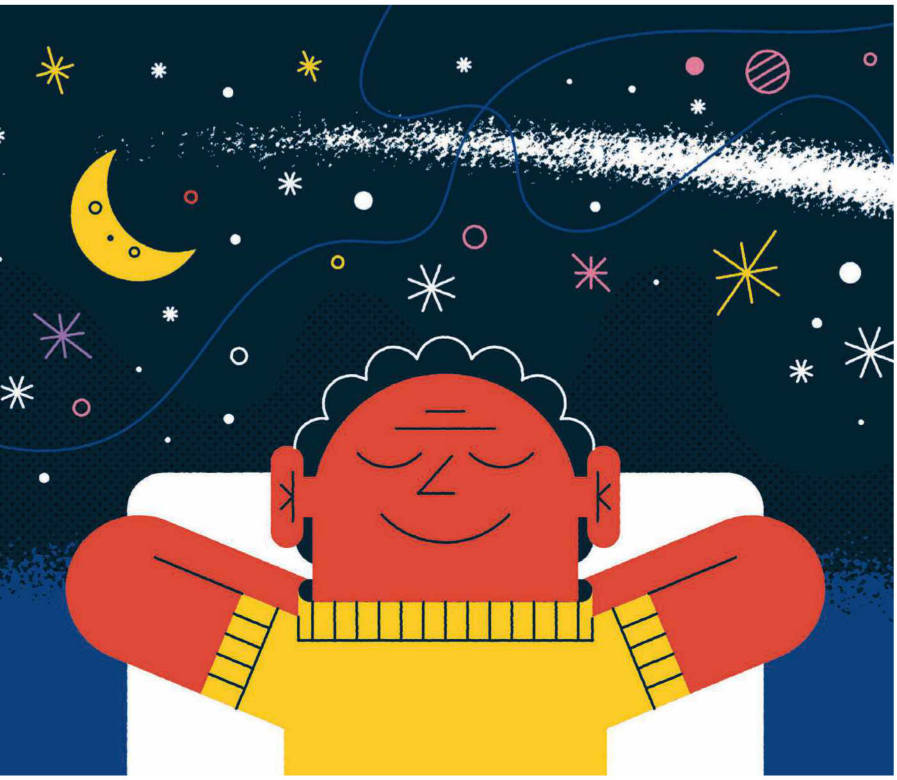
FIELD OF VIEW

Let there be less light

Light pollution, poor sleep hygiene and overstimulation are pushing our bodies out of sync. **Mark Westmoquette** explains why darkness matters now more than ever



Author of *The Mindful Universe*, astronomer and mindfulness teacher **Mark Westmoquette** lives with his young family in London and can be reached at www.markwestmoquette.co.uk

According to a growing number of scientists and doctors, many of us are no longer getting enough darkness in our lives. As human animals, we rely on the dark just as much as the light – it keeps our circadian rhythm in balance.

That rhythm is our natural sleep–wake cycle. It's why we feel alert in the morning and drowsy in the evening. Darkness stimulates the pineal gland located deep in the brain to produce melatonin, which acts to slow down our body's systems and prepare us for sleep. Maybe you've felt this: a rise in 'sleep pressure', usually about two hours before bedtime, as melatonin levels build.

As you can imagine, there are a number of consequences to our health when our circadian rhythm slips out of kilter. And one of the biggest culprits? Artificial light.

It's important to remember that our biological rhythms evolved in a time long before artificial light, when we spent much of our daylight hours outside in bright sunlight and retreated indoors as night fell. Sunlight matters: it stimulates serotonin production, lifts mood and helps us create vitamin D. But as humans, we're moving further away from daylight. The average person in the UK today spends 22 out of 24 hours indoors – that's roughly 90 per cent of our day! So yes, we need more daylight. But we also need true darkness.

In the past, dark really did mean dark. If you've ever been outside without a torch on a moonless night, far from towns and cities, you'll know: it's really dark! We're just not used to that level of darkness these days, because artificial light is everywhere.

The worst offender for upsetting our circadian rhythm is bright-white or blueish light. The old orange sodium streetlights are so much better for us than the more modern white LED ones. While warm, yellow-orange light doesn't disrupt things as much, white light is interpreted by our bodies as sunlight, telling us to wake up. It has a similarly negative effect on nocturnal animals, insects and plants too. And light pollution is getting worse. In Europe, it's increasing at a rate of 6.5 per cent every year. In North America, it's 10.5 per cent. That's huge!

Another culprit is poor sleep hygiene, the habits and behaviours that interfere with our natural sleep drive. Forcing ourselves to stay up late into the night or to get up super-early, along with bright lights, caffeine, nicotine – all go against our natural proclivity to sleep, and activate the body's 'fight or flight' stress response. Over time, this can lead to many knock-on effects, including constipation, IBS, depression, heart disease, suppression of the immune system, and even cancer.

Besides helping us to avoid this physical toll, being in darkness offers something deeper: a time of contemplation, of being and experiencing, and of potential and imagination. Being constantly surrounded by light means we miss these crucial elements of our humanity. It's easy to forget, but we need the dark as much as we need the light.

JOHN DEVOLLE, FOLIO

BBC Sky at Night MAGAZINE

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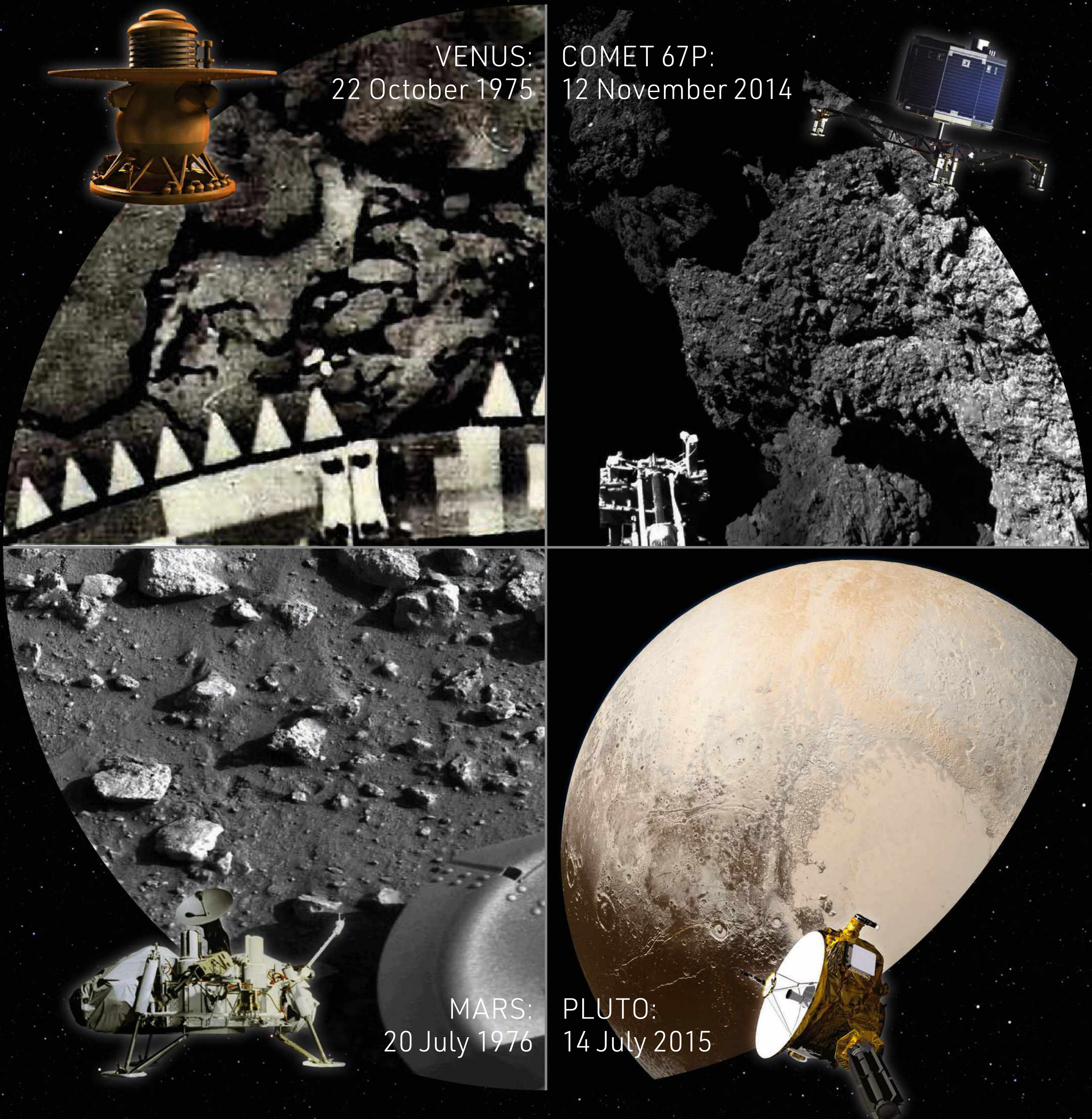
News

FIRST CONTACT

Seven missions that gave us our first real look at alien worlds

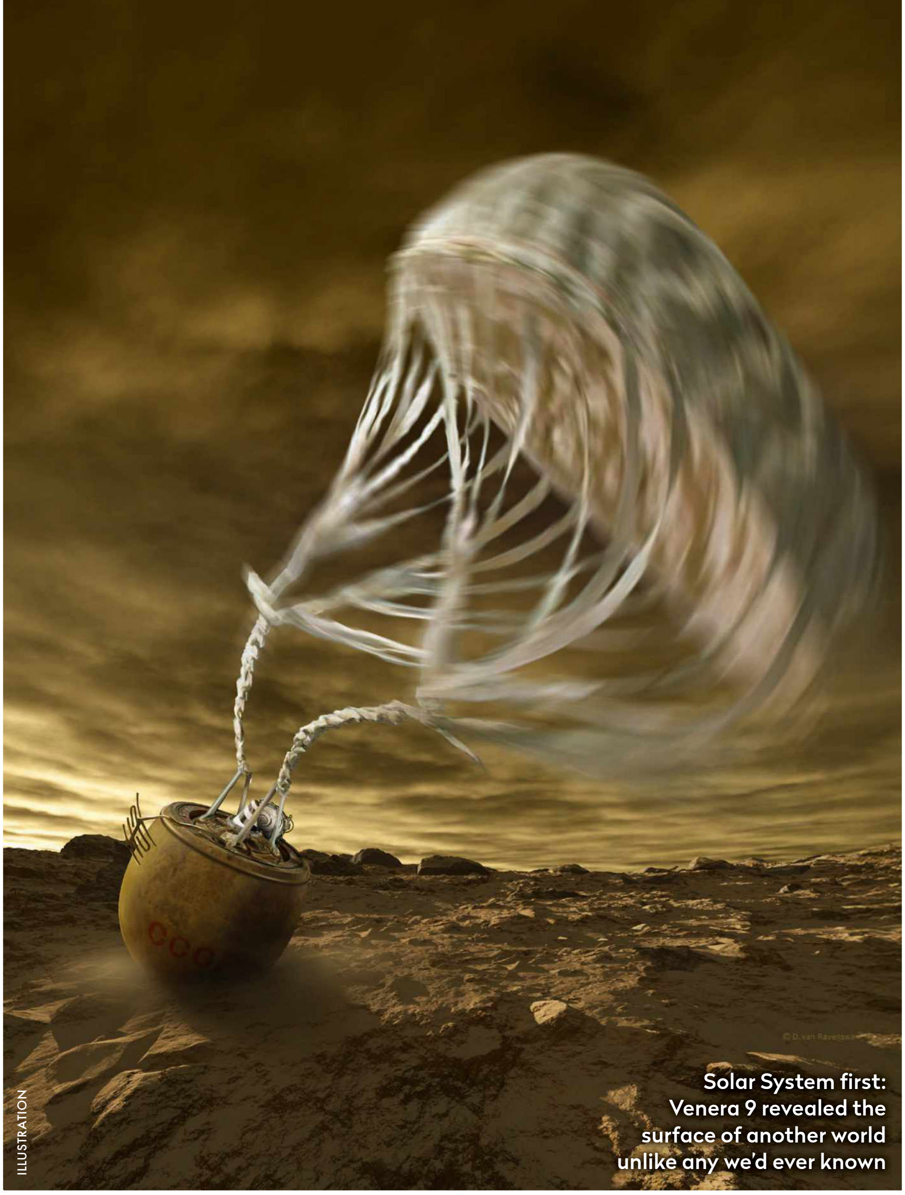

VENUS:
22 October 1975
COMET 67P:
12 November 2014
MARS:
20 July 1976
PLUTO:
14 July 2015

It's half a century since humanity captured the first images from the surface of an alien world. **Giles Sparrow** explores the pioneering missions that have brought us face to face with our Solar System neighbours

This October marks 50 years since a heavily shielded spacecraft, the Soviet Union's Venera 9, parachuted into the atmosphere of Venus. Then, having landed, it did something extraordinary: it beamed back the first images ever captured from the surface of another planet. The pictures of its baking hot terrain marked a huge leap forward in our understanding of our nearest planetary neighbour.

But it was just one of many missions to revolutionise Solar System science. Space probes have now returned close-ups of all the major planets, countless moons and many smaller objects. Some made fly-bys, while others stayed in orbit to conduct detailed surveys. Several landed. Some even drove across the alien surface. Here we recall some of those first encounters, the ingenious science and engineering they required, and the extraordinary images that reshaped our view of our corner of the cosmos.

Giles Sparrow is a science writer and a fellow of the Royal Astronomical Society



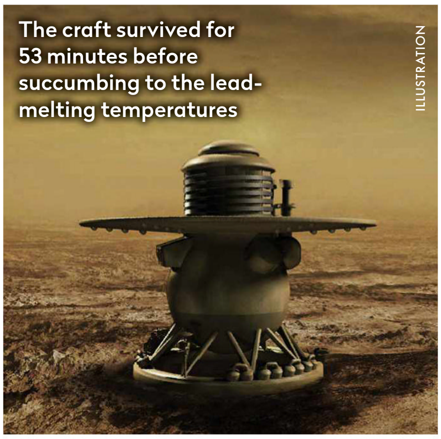
Solar System first: Venera 9 revealed the surface of another world unlike any we'd ever known

Venera 9 on Venus: 53 minutes in hell

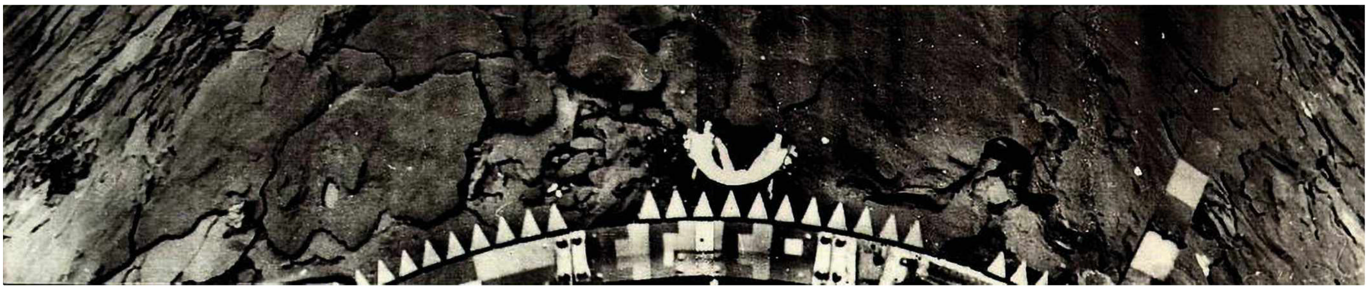
Venera 9 was the sixth spacecraft to brave Venus's thick, corrosive atmosphere, and built on lessons from earlier missions to survive the punishing descent and extend its survival on the hostile surface. Electronic video cameras were mounted on either side of the lander, but a jammed lens cap meant that only one was able to return images.

Angled slightly downwards to capture views stretching from foreground to horizon, the working camera used a pivoting mirror system to slowly 'look around', building a wide-angle panoramic video image. In its 53 minutes of operation before contact was lost, it scanned 174° from left to right, and got two-thirds of the way through a reverse pass.

Each video frame contained just 500 rows of 117 individual picture elements (pixels). The camera's fluctuating output was converted into digital brightness levels ranging from 0 to 63, then transmitted to the lander's orbiter mothership for relay to Earth. Meanwhile, separate instruments recorded surface light conditions, which were a vital part of accurate image processing. ▶

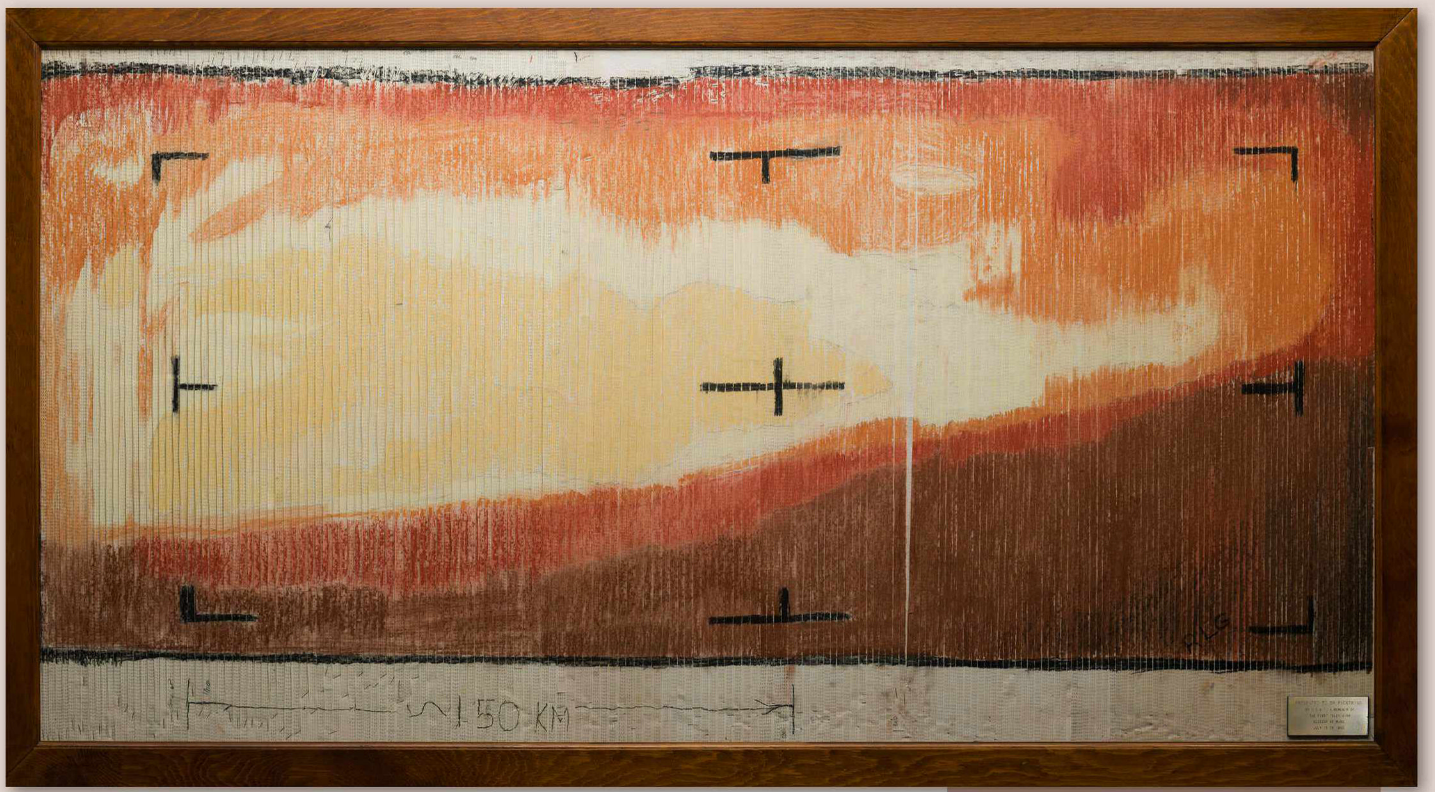


The craft survived for 53 minutes before succumbing to the lead-melting temperatures



▲ Venera 9's panorama, captured on 22 October 1975, was humanity's first-ever photograph captured from the surface of another planet

PAGE 28 IMAGE: PHOTOS: NASA | ESA, ROSETTA, MPS FOR OSIRIS TEAM MPS, UPD, LAM, IAA, SSO, INTA, UPM, DASP, IDA | NASA, JPL | NASA, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY, SOUTHWEST RESEARCH INSTITUTE, ALEX PARKER | SPACECRAFT ILLUSTRATIONS: STEVEN HOBBS, STOCKTREK IMAGES, ALAMY | ESA, C. CARREAU, ATG MEDIALAB | NASA | JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY, SOUTHWEST RESEARCH INSTITUTE | **PAGE 29 IMAGES**: DETLEV VAN RAVENSWAAY, SCIENCE PHOTO LIBRARY | STEVEN HOBBS, STOCKTREK IMAGES, ALAMY | NASA

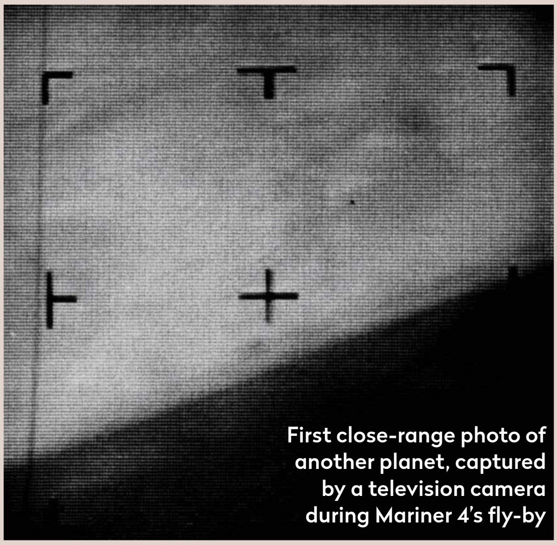


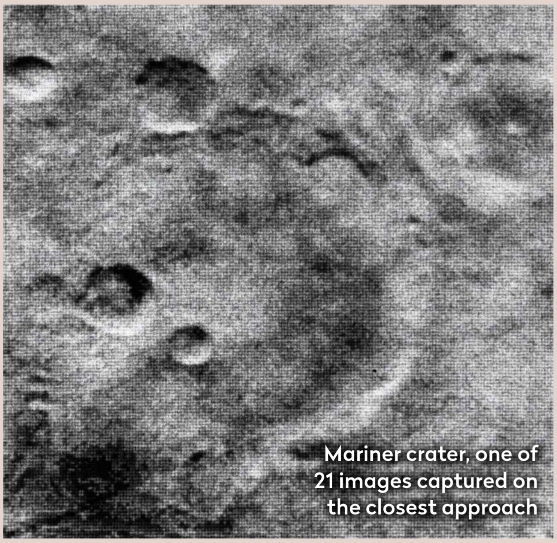
▲ Paint by numbers: Mariner 4's data took so long to receive and process that eager NASA scientists made hand-coloured versions while they waited

Mariner 4 puts Mars on TV

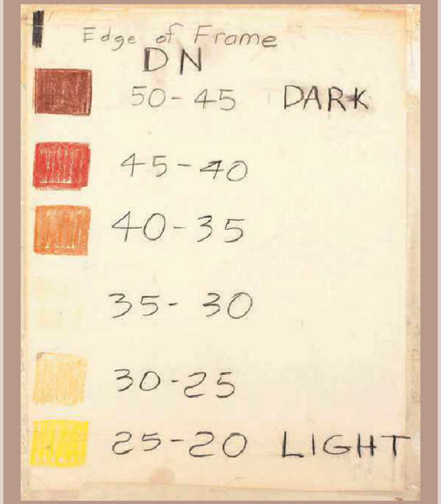
Scroll back 10 years from Venera 9 and we reach the very first detailed images of (as opposed to from) another planet's surface, returned during Mariner 4's fly-by of Mars in July 1965. As one of the earliest missions to carry television technology beyond Earth orbit, Mariner 4 was able to produce images directly in the form of varying electric signals. Light gathered by the onboard telescope was directed onto a camera tube, forming an image on a metal 'storage plate'. Brighter areas generated stronger electric charges. An electron beam then scanned across the plate, discharging it to produce a stream of electrical signals, 200 rows of 200 pixels each.

Mariner 4 returned 21 images of Mars in total, but with 40,000 bits of data per image, it took eight hours to receive just one, and even longer for computers to process it. Impatient to see the results, mission scientists printed out the incoming data one strip at a time and hand-coloured the numbers to match brightness levels, creating the first close-up image of Mars by hand.


First close-range photo of another planet, captured by a television camera during Mariner 4's fly-by

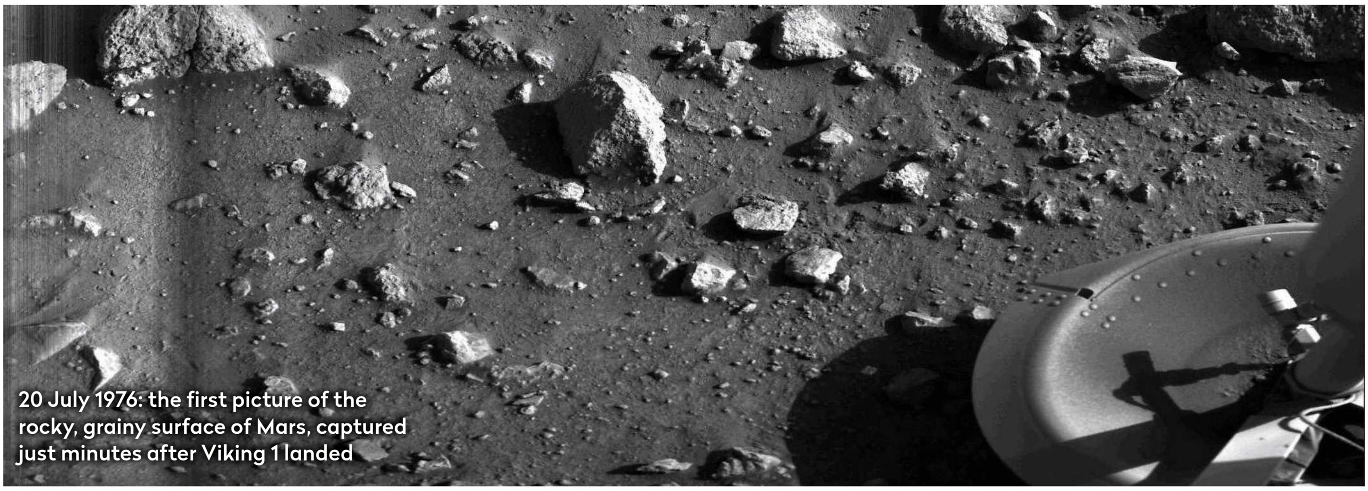

Mariner crater, one of 21 images captured on the closest approach

▲ Once the data was converted into numbers, they printed it in strips and attached them to a panel to crayon


Edge of Frame
DN
50-45 DARK
45-40
40-35
35-30
30-25
25-20 LIGHT

▲ The key used to colour-code the camera's digital brightness values to make the 'first image' collage

NASA, JPL-CALTECH, DAN GOODS X 3 | NASA, JPL X 2 | NASA, JPL-CALTECH | DETLEV VAN RAVENSWAAY, SCIENCE PHOTO LIBRARY | NASA

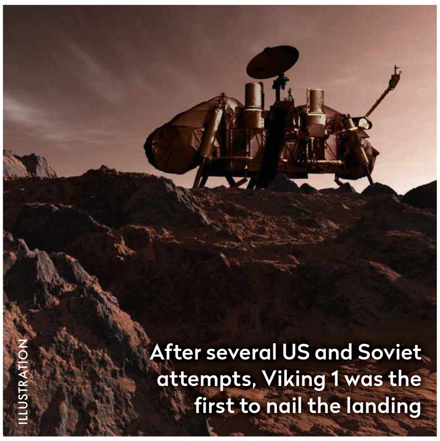


20 July 1976: the first picture of the rocky, grainy surface of Mars, captured just minutes after Viking 1 landed

Viking 1: stills from the Martian surface

On 20 July 1976, NASA's Viking 1 lander transmitted the first picture from the surface of the Red Planet. The lander (and its identical twin, which landed several weeks later) was fitted with two advanced solid-state video cameras. These used a movable scanning mirror to direct light from a very narrow field of view onto 12 silicon-based diodes. Six of the diodes were sensitive to wavelengths of visible and infrared light, while others captured monochrome images focused at different distances. Initial processing failed to correct for light conditions on Mars, resulting in images of a blue sky and pinkish landscape. It was only after proper calibration that the rusty terrain and pink-hued sky were properly revealed.

In total, the Viking landers returned some 4,500 images of their surroundings, but this was just the beginning for Martian imaging – more recently, rover missions have carried multiple CCD cameras (see Philae, overleaf) to collect a wealth of data as they explore the surface. For example, the Mars Curiosity rover, which landed in 2012, has so far returned more than 700,000 raw images.



ILLUSTRATION

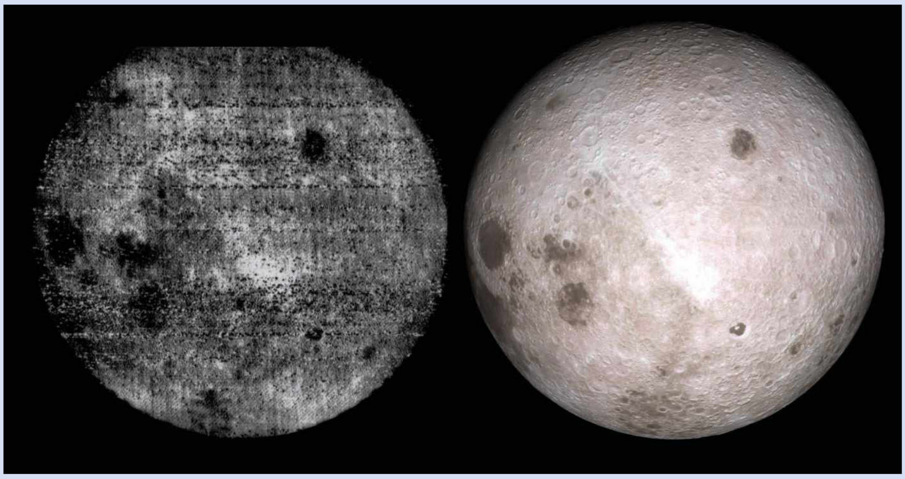
After several US and Soviet attempts, Viking 1 was the first to nail the landing

Luna 3: first glimpse of the Moon's far side

Some 17 years earlier than Viking 1, in October 1959, a far less complex mission delivered the first close-up pictures taken from space of another world: the hidden far side of the Moon.

Even getting the target in the frame was a major challenge for the designers of the Soviet probe Luna 3. With computing in its infancy, and the precise star-based orientation used by later probes unimaginable, their ingenious solution was to use a light sensor to aim the spacecraft directly towards the Sun. Because the fly-by was timed for the new Moon (when the far side would be fully illuminated), the Moon therefore lay directly behind the spacecraft and lined up with its rear-facing camera. Once Luna 3 had passed the Moon, it looked back and captured a series of 29 images.

Its camera used traditional photographic film. With no way of returning this to Earth, its images had to be converted to a format suitable for radio signals. Once the film was chemically developed in an automatic processor, a bright spot of light was shone through the negative, moving back and forth in parallel lines. An electronic detector captured the transmitted light and generated an electrical representation of the image's varying brightness for recording onto magnetic tape and later transmission. ▶



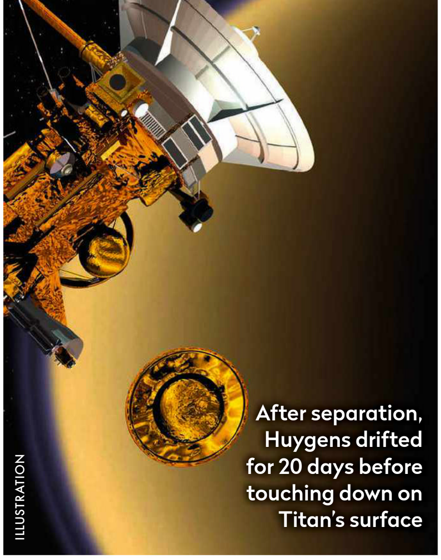
▲ **The carefully timed fly-by revealed the far side's heavily cratered surface, notably lacking lunar maria. A 2009 image of the same region is shown for comparison**

Huygens on Titan: touchdown on Saturn's moon

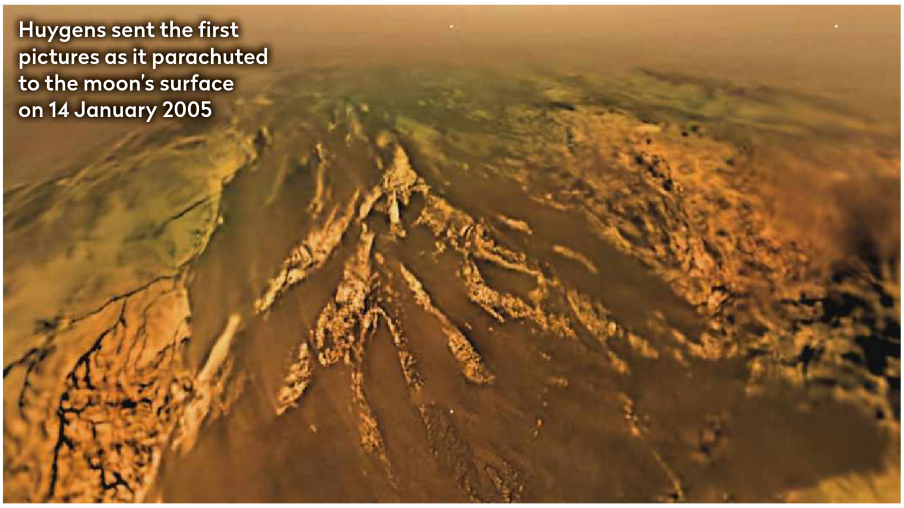
The cloud-covered giant moon Titan was a key target for exploration during planning of NASA's ambitious Cassini Saturn-orbiter mission. Yet the European Space Agency (ESA) Huygens lander, which hitched a ride on the orbiter, nearly ended up compromising the mission.

The shield-shaped lander was equipped with a variety of cameras and other instruments, but relied on Cassini as a communications relay. Months after the mission's 1997 launch, cautious ESA engineers ran simulations of the descent and realised that, because Huygens would be accelerating away from Cassini, vital radio signals between the two would be scrambled by the stretching of waves known as the Doppler effect.

Since it was now impossible to reprogramme the spacecraft's computers, the only solution was to alter the flightpaths, delaying the Huygens lander's release to reduce acceleration between the two craft during the descent. When Huygens finally parachuted into Titan's clouds on 14 January 2005, its cameras revealed a strangely Earth-like landscape shaped by liquid hydrocarbons flowing across the surface.



After separation, Huygens drifted for 20 days before touching down on Titan's surface

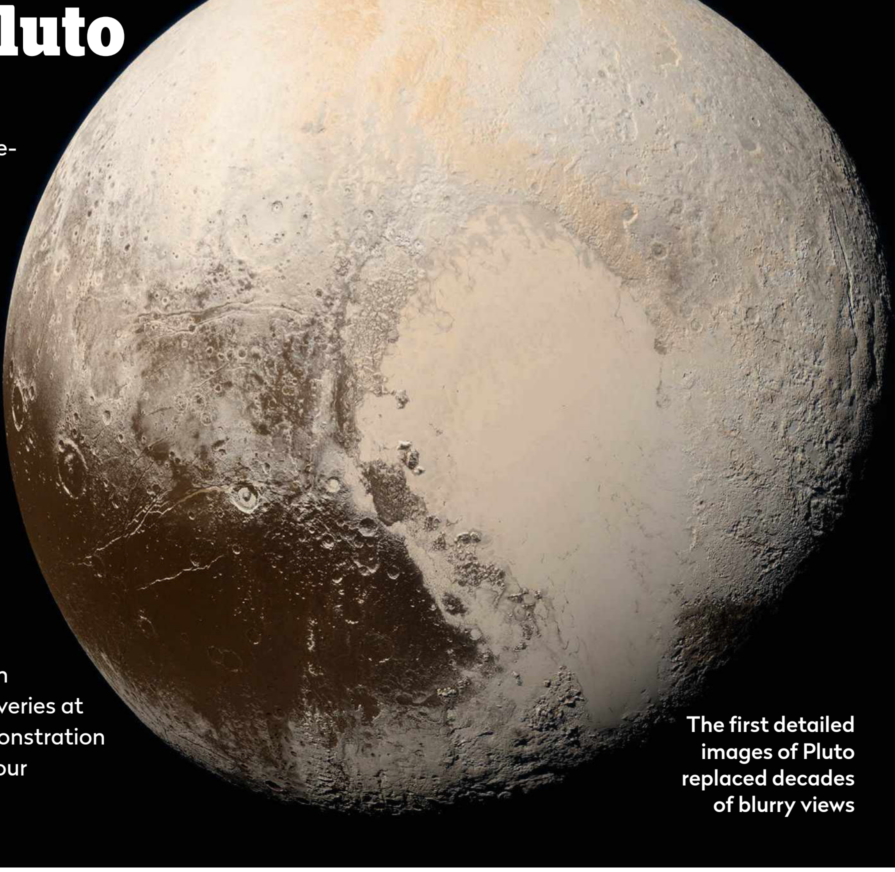


Huygens sent the first pictures as it parachuted to the moon's surface on 14 January 2005

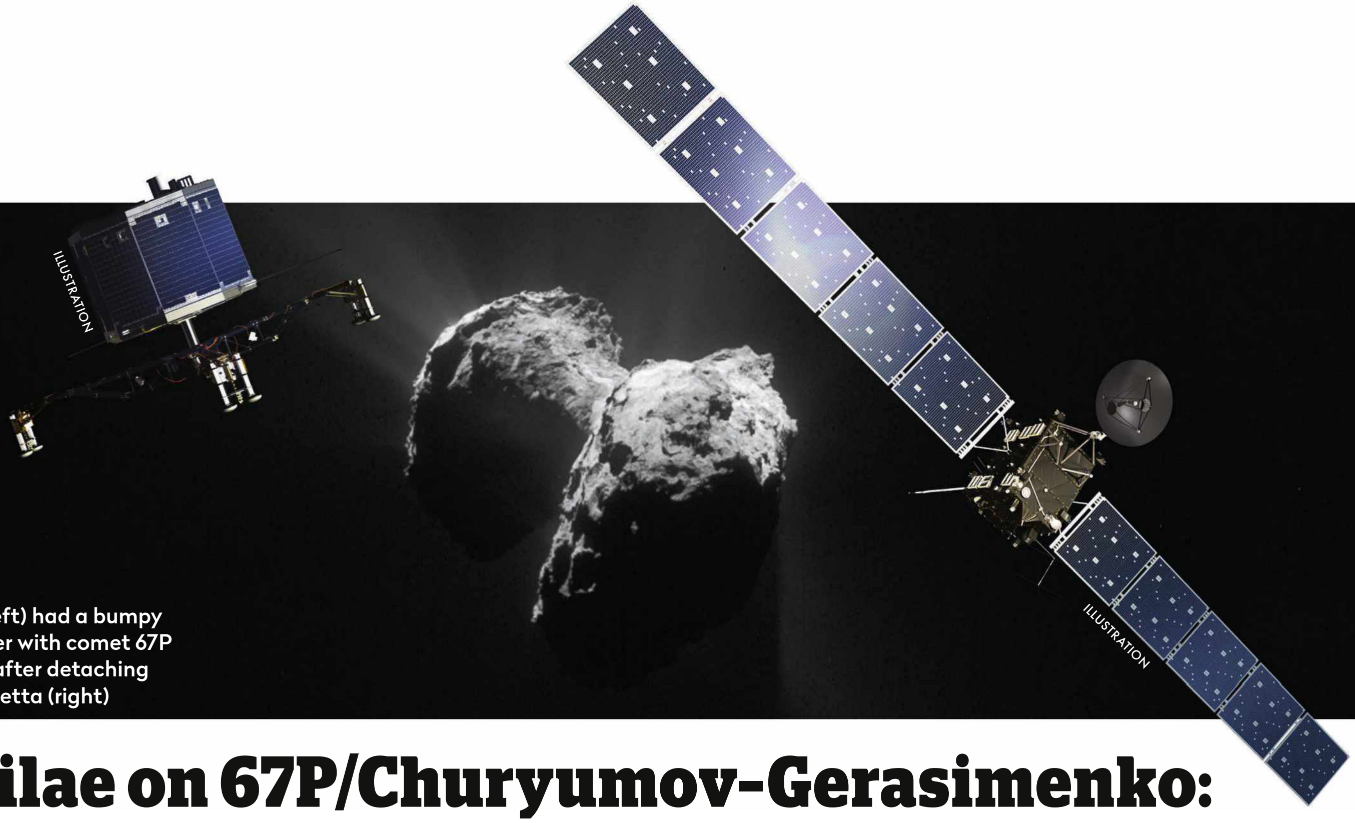
New Horizons: postcard from Pluto

On 14 July 2015, NASA's New Horizons mission delivered some of the most ambitious of all space-based imaging to date, returning pictures from a twilight zone beyond Neptune. At Pluto's distance, sunlight is 1,000 times weaker than on Earth, so the probe's cameras were designed to sweep up as much light as possible. The CCDs used pixels 100 times larger than those in a typical Earth-based device. A narrow-angle instrument called LORRI captured highly magnified views on a square array 1,024 pixels wide, while the wide-angle camera Ralph – with a resolution of 5,024 by just 32 pixels – built larger images by scanning the surface continuously throughout the high-speed fly-by.

Pluto was widely expected to be a deep-frozen ice ball with ill-defined patchy features. Instead, the cameras revealed a complex world of bright plains shaped by recent icy eruptions, wind-blown dunes and towering mountains of ice. Such discoveries at the edge of the Solar System are a powerful demonstration of how much our ideas can change when we see our neighbouring worlds up close.



The first detailed images of Pluto replaced decades of blurry views

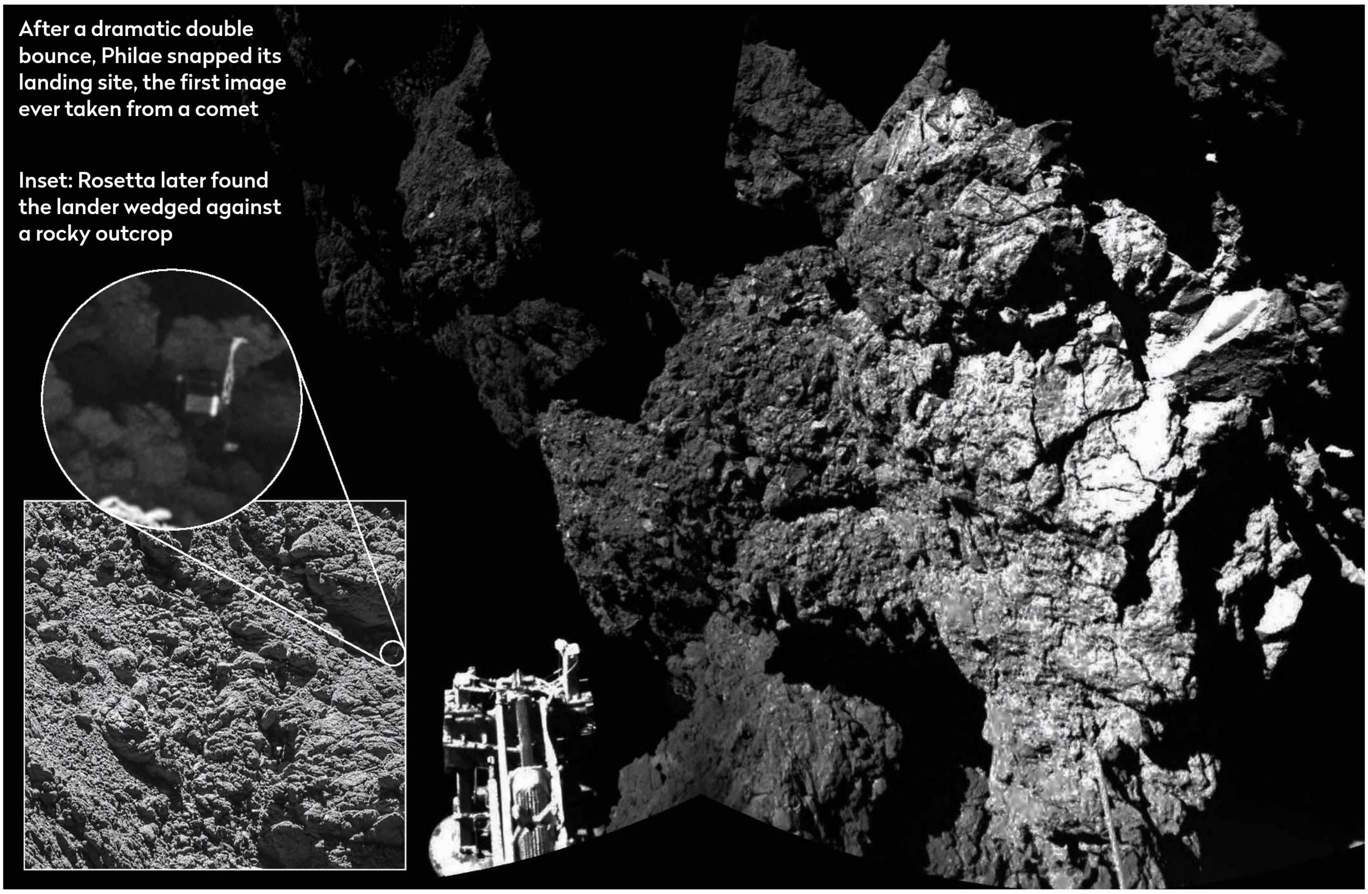


Philae (left) had a bumpy encounter with comet 67P (centre) after detaching from Rosetta (right)

Philae on 67P/Churyumov-Gerasimenko: bouncing onto a comet

On 12 November 2014, ESA's Philae lander became the first spacecraft to send back images from the surface of a comet. It was deployed by Rosetta, which had entered orbit around the comet 67P/Churyumov–Gerasimenko some three months earlier. A hazardous landing saw the 100kg (220lb) craft bounce twice in the comet's weak gravity before coming to rest in the shadow of a cliff. With limited sunlight reaching its solar panels, its battery ran down after 57 hours – but not before it had sent back images, including a panoramic view of its final landing site.

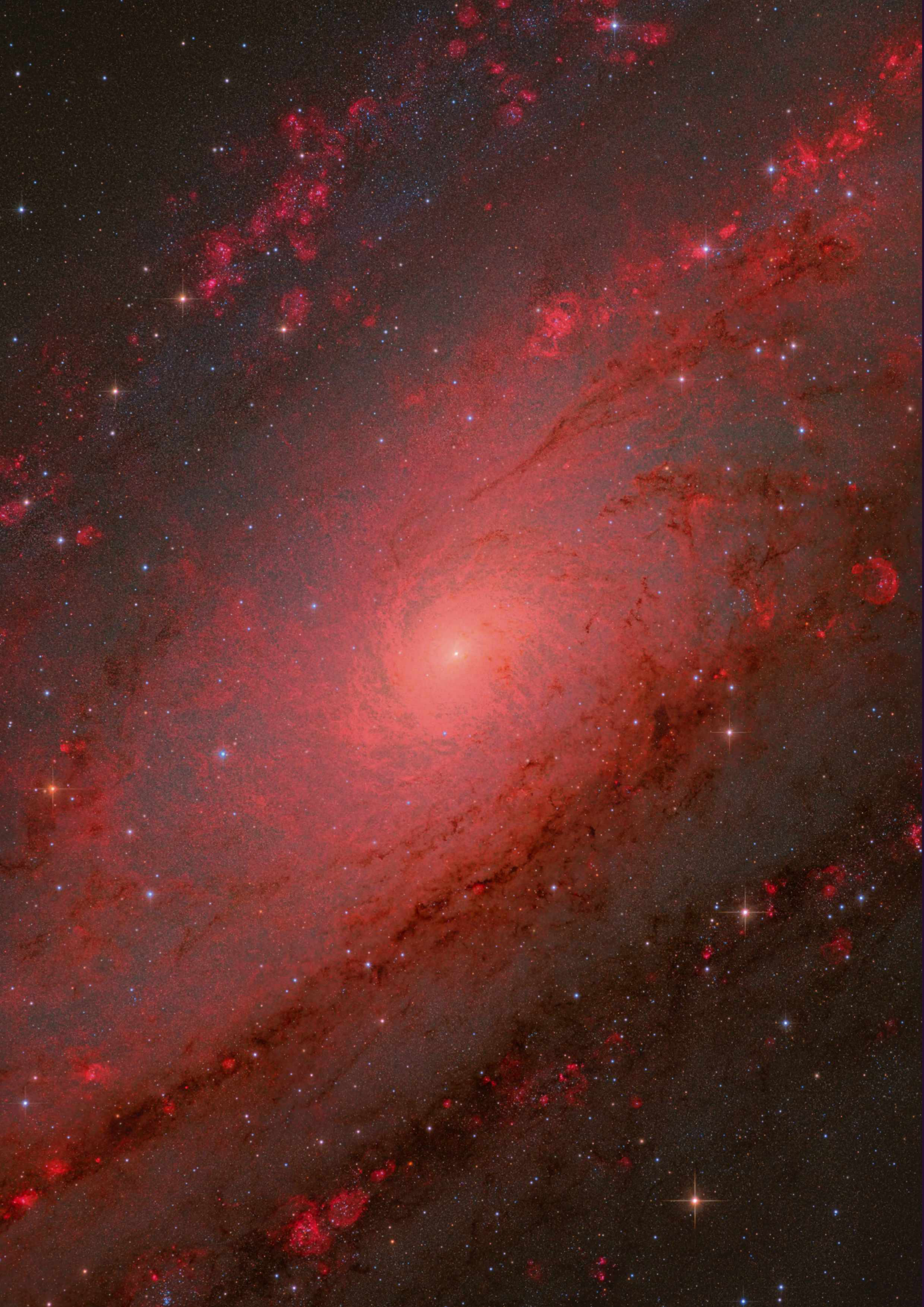
Philae's cameras, like those of most modern probes, used modified versions of the same CCD (charge-coupled device) chips found in consumer digital cameras. Essentially an array of tiny light-sensitive diodes arranged on a silicon wafer, this technology was pioneered in space by another European comet mission, the 1986 Giotto probe which captured over 2,000 images of Halley's Comet.



After a dramatic double bounce, Philae snapped its landing site, the first image ever taken from a comet

Inset: Rosetta later found the lander wedged against a rocky outcrop

AFP, GETTY | ESA, NASA, JPL, UNIVERSITY OF ARIZONA | NASA, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY, SOUTHWEST RESEARCH INSTITUTE, ALEX PARKER | ESA, ROSETTA, NAVCAM | ESA, C. CARREAU, ATG MEDIALABX 2 | ESA, ROSETTA, PHILAE, CIVA | ESA, ROSETTA, MPS FOR OSIRIS TEAM MPS, UPD, LAM, IAA, SSO, INTA, UPM, DASP, IDA



Astronomy Photographer of the Year

BBC Sky at Night Magazine is thrilled to reveal the 2025 winners in the globe's premier astrophotography contest

The winners of the world-famous Astronomy Photographer of the Year 2025 awards have been announced – and the results are stunning.

Space enthusiasts from all over the globe competed, with 1,141 individuals submitting a total of 5,882 entries, all hoping to impress the judges. With eight subject categories, as well as special prizes for newcomers, one that recognises the best photo processed using any form of astronomical data, and the ZWO Young Astronomy Photographer of the Year, the competition was fierce. You can see the winning photos for yourself at the National Maritime Museum in Greenwich, London from 12 September. To find details, visit **www.rmg.co.uk/astrophoto**.

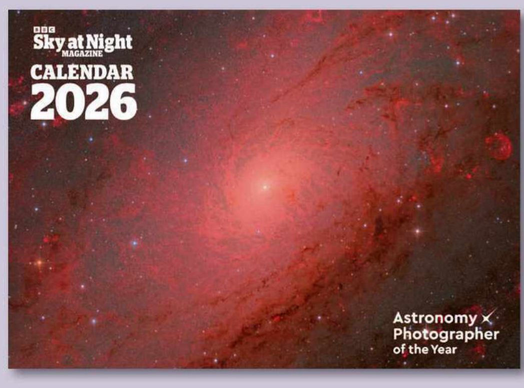
◁ OVERALL WINNER / Galaxies

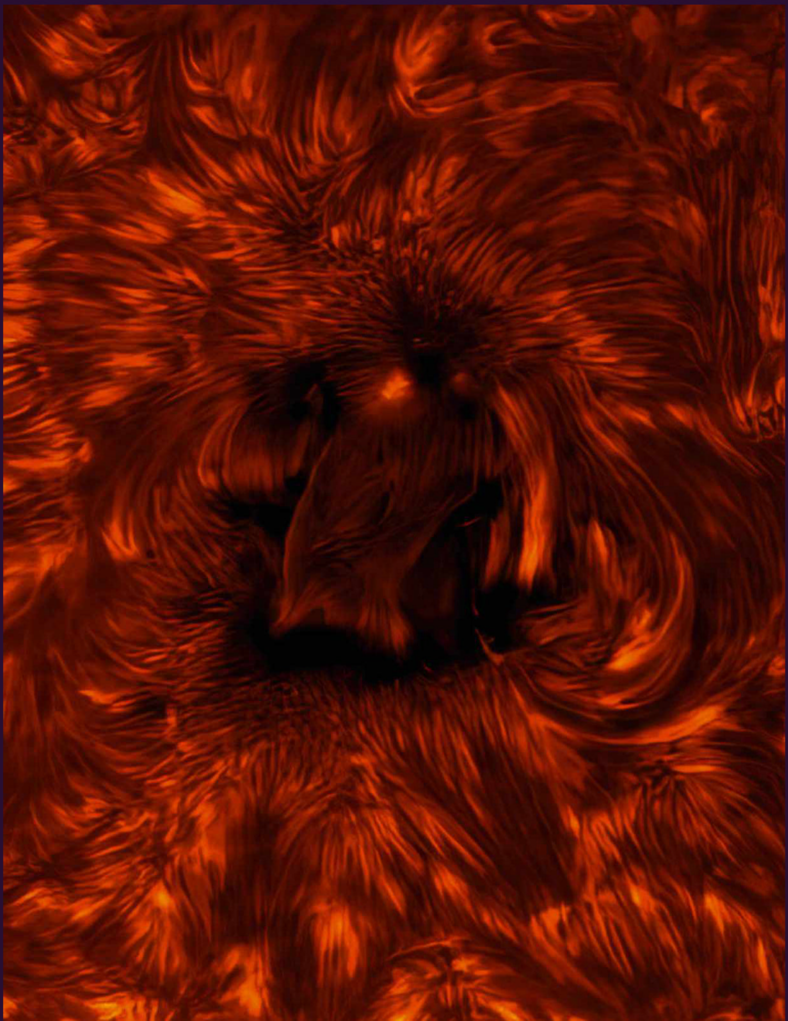
The Andromeda Core
Weitang Liang, Qi Yang and Chuhong Yu

Location: AstroCamp Observatory, Nerpio, Spain
Equipment: PlaneWave CDK20 telescope, Baader LRGB and Chroma H-alpha filters, PlaneWave L500 mount, Moravian C3-61000 Pro camera, focal length 3,450mm, 500mm f/6.8, multiple 900-second RGB exposures, multiple 1,800-second H-alpha exposures, 38 hours total
Judge's verdict: "Not to show it all – this is one of the greatest virtues of this photo. The Andromeda Galaxy has been photographed in so many different ways, it's hard to imagine a photo would ever add to what we've already seen. But this does just that: an unusual, dynamic composition, with unprecedented detail that doesn't obscure the overall scene."
– László Francsics

FREE 2026 CALENDAR

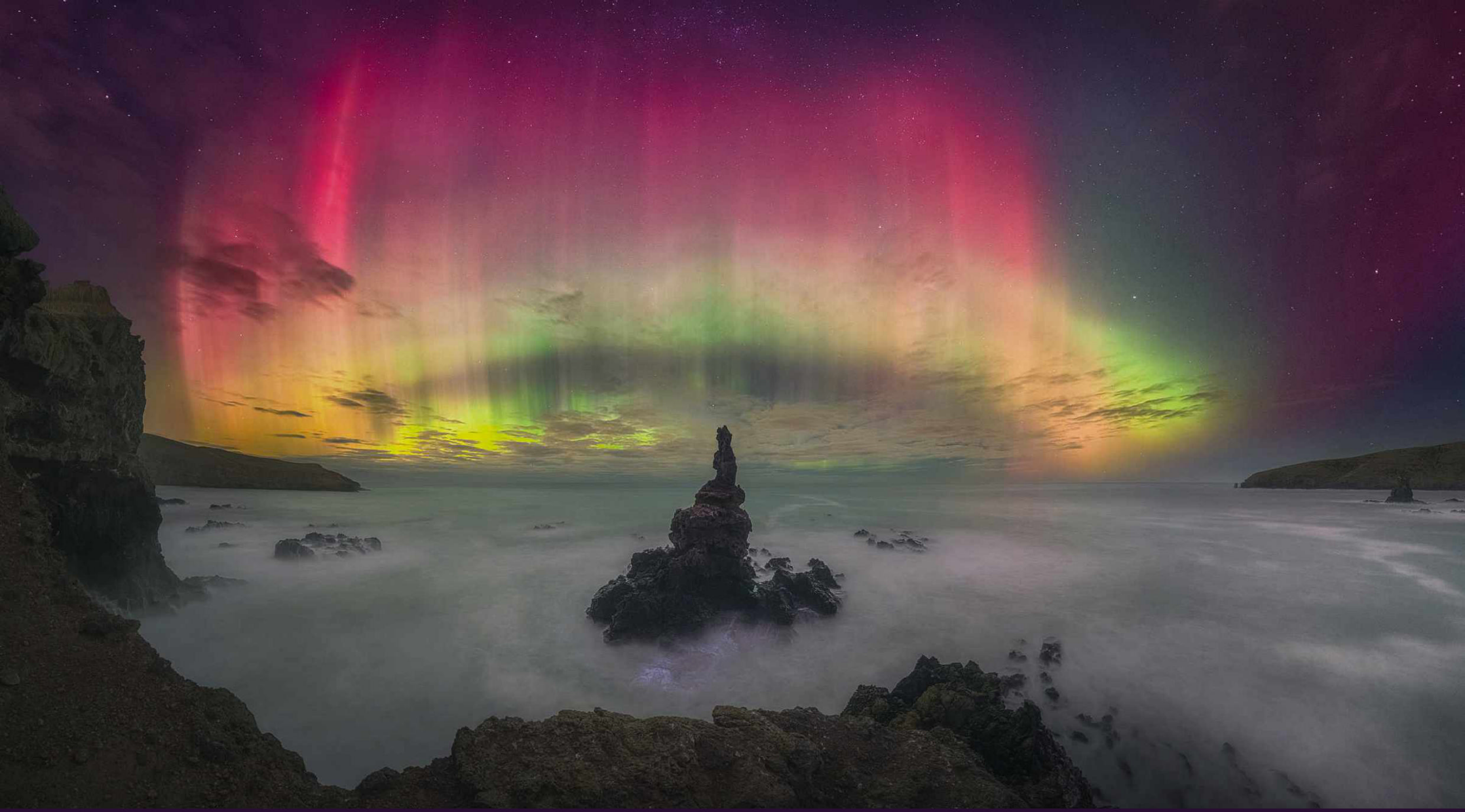
Don't miss the December issue of *BBC Sky at Night Magazine* for our free 2026 calendar, featuring all the winning images from the competition, as well as details of all the year's unmissable astronomical events. It goes on sale from 18 November 2025.

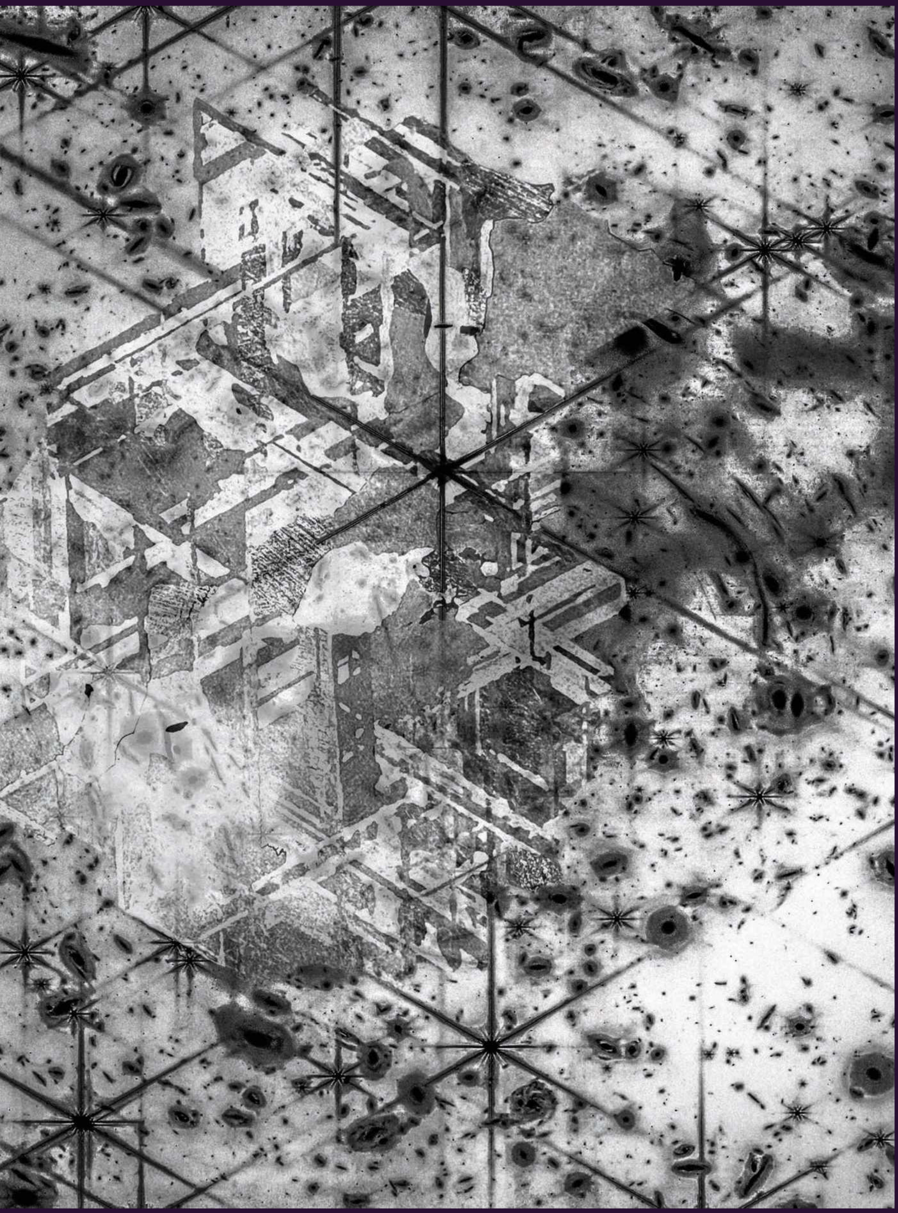




◁ Our Sun

Active Region of the Sun's Chromosphere
James Sinclair
Location: Cedar City, Utah, USA
Equipment: Lunt 130mm telescope with double-stacked etalons, Lunt B3400 blocking filter (34mm), Sky-Watcher EQ6R-Pro mount, Player One Astronomy Apollo-M Max camera, 910mm f/28, gain 310, 10-second exposure
Judge's verdict: "I found this amazingly detailed view of one tiny portion of the Sun's surface totally mesmerising. Its abstract beauty wonderfully conveys constant movement and it screams pure fusion energy!" **– Martin Lewis** ▶





△ Aurorae

Crown of Light

Kavan Chay

Location: Tumbledown Bay, Little River, Banks Peninsula Community, New Zealand

Equipment: Nikon Z7 astro-modified camera, Sky-Watcher Star Adventurer Pro 2i mount, Nikkor Z 14–24mm f/2.8 S, 16mm, sky f/2.8, ISO 800, 5-second exposure, foreground f/5.6, ISO 3200, 30-second exposure

Judge's verdict: "This breathtaking panoramic image, taken during an intense G5 storm, captures the vibrant Aurora Australis. Its strength lies in the balance of technical precision and emotional resonance. The rocky coastline anchors the scene, contrasting with the ethereal glow of the aurora." **– Yuri Beletsky**

◁ SPECIAL PRIZE: The Annie Maunder Open Category

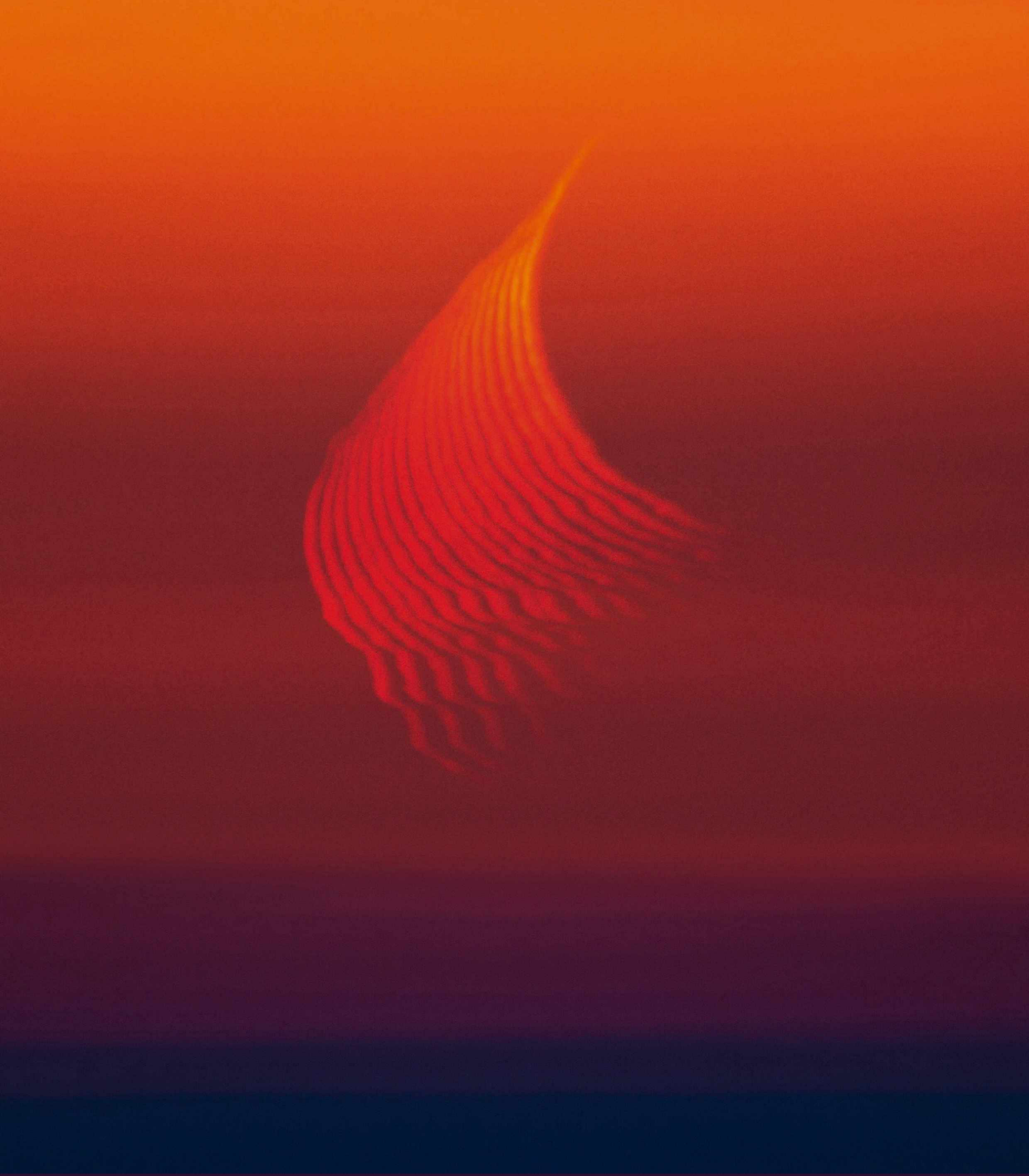
Fourth Dimension

Leonardo Di Maggio

Original data: JWST, NIRCam, Near-Infrared, NASA, ESA, CSA, STScI from 12 July 2022

This image combines James Webb Space Telescope data with a photograph of the inside of a meteorite. Both have been converted to black and white and merged, with the meteorite layer set to low opacity so the JWST data bleeds through, creating a surreal, hazy effect.

Judge's verdict: "This image unites two phenomena typically hidden from view: gravitational lensing [the bending and magnification of light from distant objects by massive foreground bodies] captured by the JWST, and the intricate internal structure of a meteorite. Together, they form a striking composite that bridges the vastness of the cosmos with the minuteness of the microscopic." **– Victoria Lane**

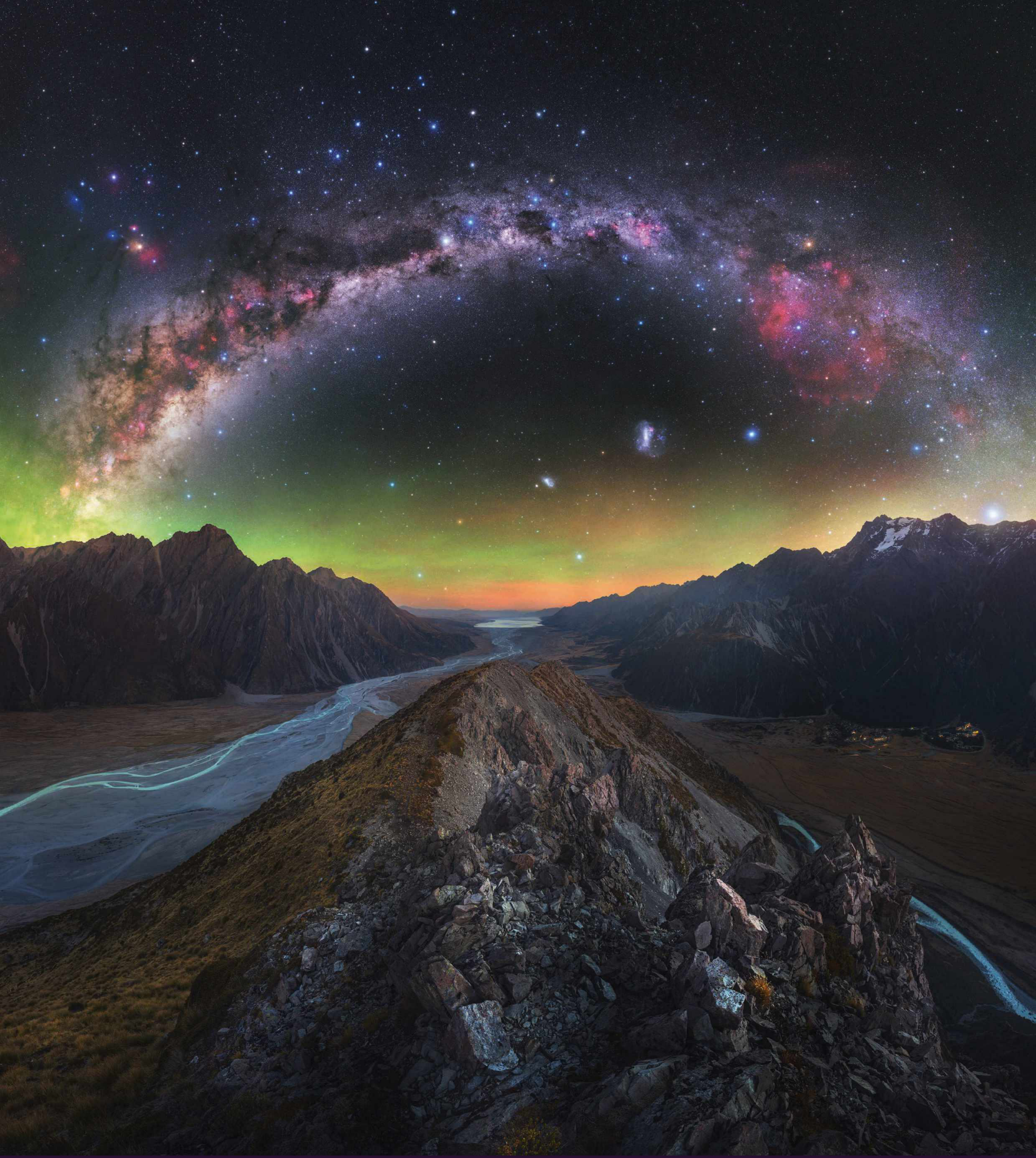


△ Our Moon

The Trace of Refraction

Marcella Giulia Pace

Location: Contrada Sant'Ippolito, Modica, Sicily, Italy
Equipment: Nikon D7100 camera, 600mm f/6.3, ISO 100, 1-second exposure
Judge's verdict: "We often see pictures of the Moon setting, the distortion of the atmosphere playing with its contours. But this image vividly shows just how much distortion is possible at the very edge of the horizon, stretching and wrinkling the lunar limb as if the ground is a black hole drawing the Moon towards it. A single sliver from it would be beautiful in its own right, but when part of a well-crafted sequence it becomes a fascinating montage of a daily occurrence we never get to see in this way." **– Steve Marsh** ▶



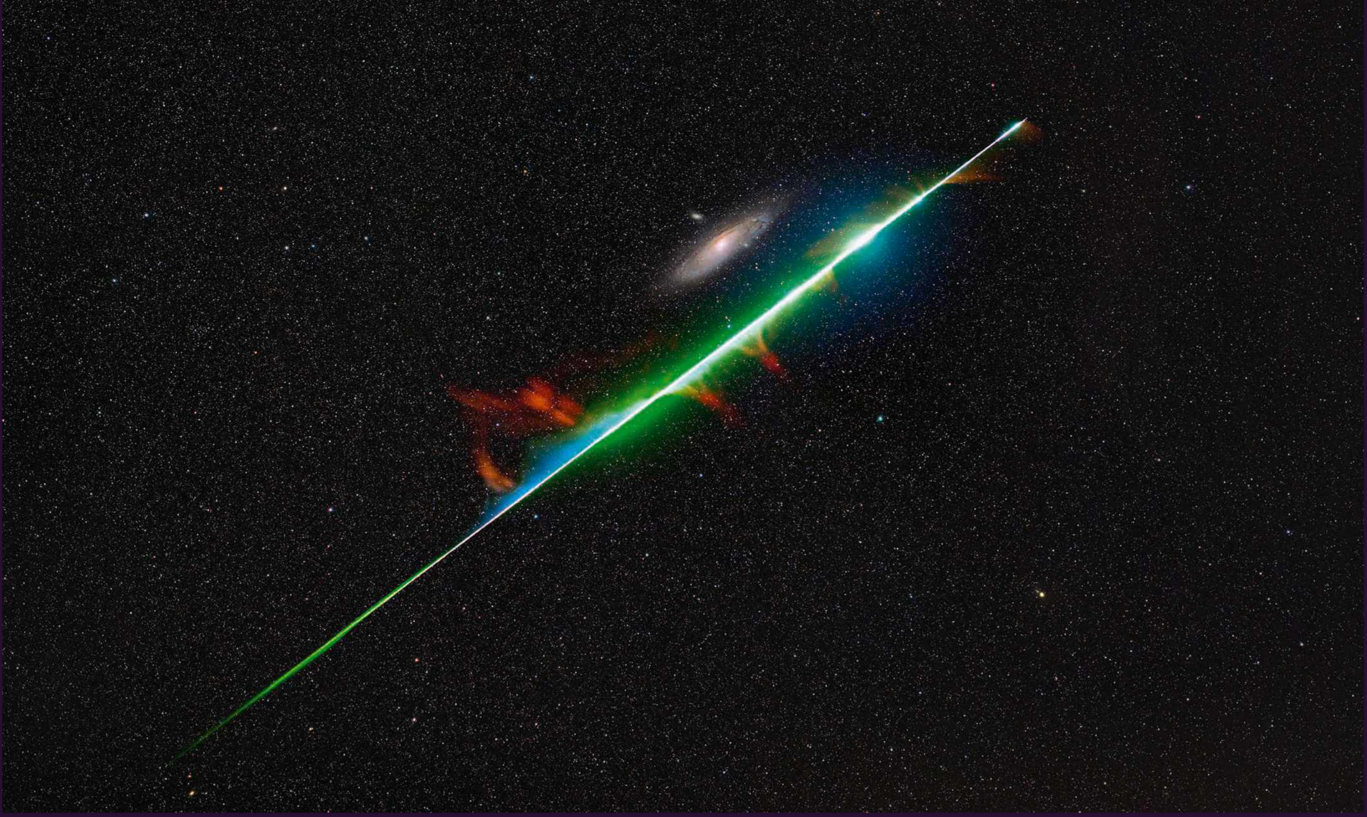
△ Skyscapes

The Ridge

Tom Rae

Location: Aoraki/Mount Cook National Park, Mackenzie District, New Zealand
Equipment: iOptron SkyGuider Pro mount, sky: Nikon Z6a camera, 40mm f/1.8, ISO 1600, 49x 30-second exposures, foreground: Nikon Z7 camera, 28mm f/10, ISO 125, 13x 20-second exposures

Judge's verdict: "There is so much to love in this image. It is absolutely breathtaking. The vibrant colours of the landscape, the night sky and the individual stars are all remarkable. The photographer has captured impressive depth in the Milky Way, including the added hydrogen regions, without overdoing it. I appreciate how the airglow appears to cradle the sky, and the landscape contributes to a very balanced composition. Truly eye-catching and dreamy."
– Kerry-Ann Lecky Hepburn



△ SPECIAL PRIZE: Sir Patrick Moore Prize for Best Newcomer

Encounter Across Light Years

Yurui Gong and Xizhen Ruan

Location: Zhucheng City, Shandong, China

Equipment: Nikon Z30 camera, 56mm f/1.7, ISO 800, multiple 30-second exposures

Judge's verdict: "Happenstance created this alluring comparison. Our view of Andromeda is fixed, whereas rocky material burning up in our atmosphere flares up as a fireball for just a few seconds. For just a moment, the annihilation of an object no bigger than a football steals the attention from the home of over a trillion stars." **– Ed Bloomer**

▽ Stars and Nebulae

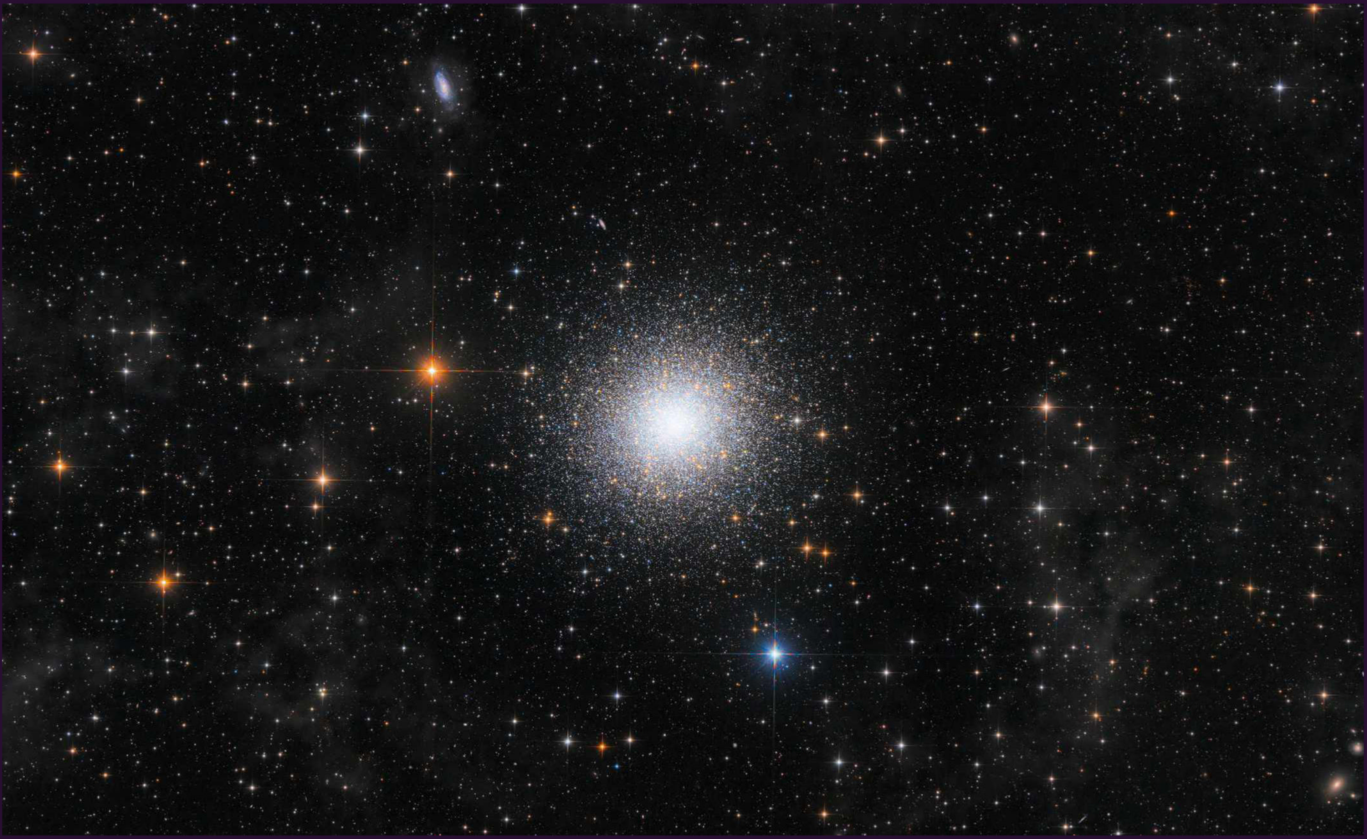
M13: An Ultra-Deep Exposure of the Popular Cluster

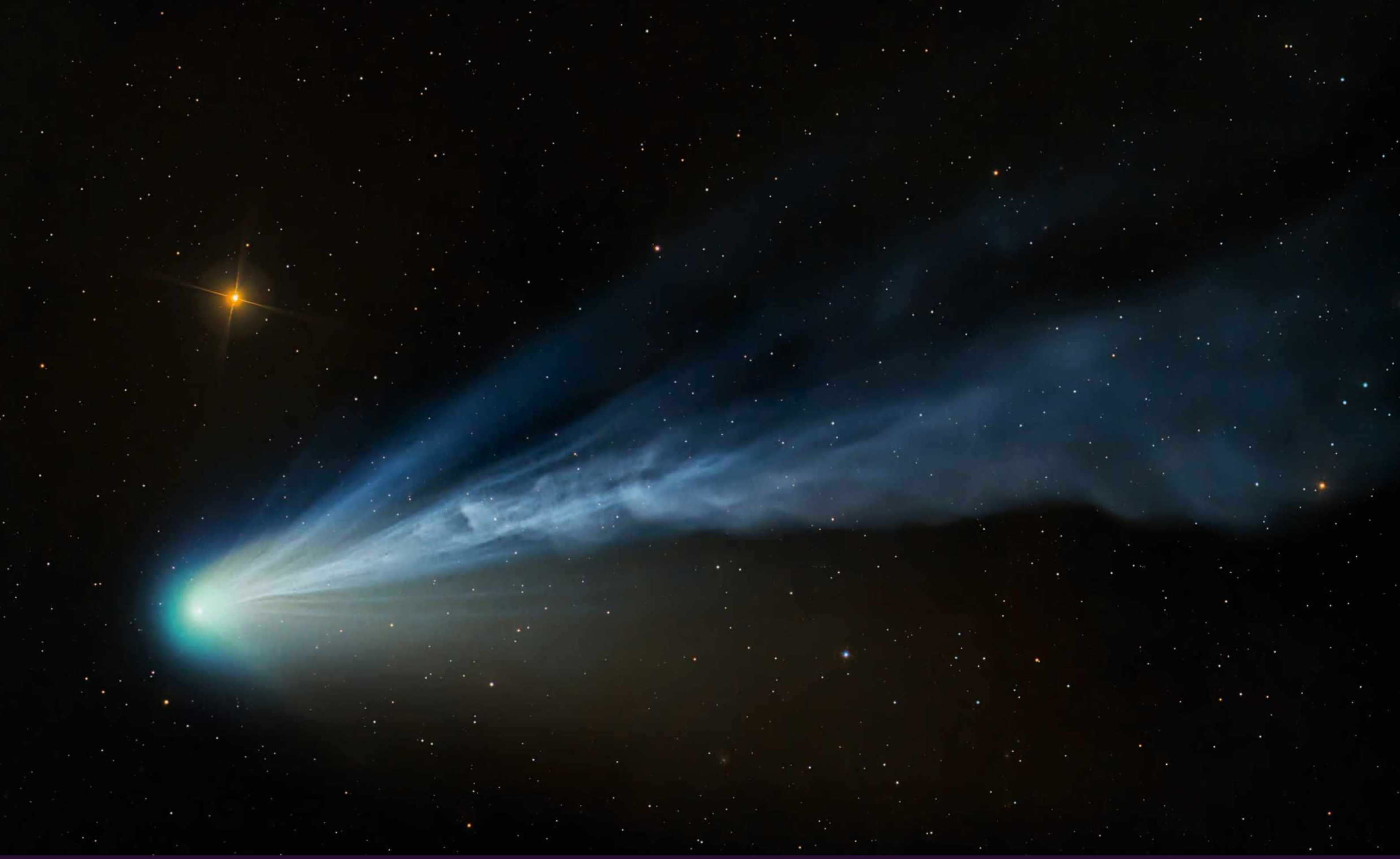
Distant Luminosity astrophotography collective

Location: Pena Trevinca, Veiga, Gijón municipality, Asturias, Spain

Equipment: TS-Optics 8-inch ONTC f/4 Newtonian telescope, iOptron CEM70G mount, ZWO ASI2600MM Pro camera, 800mm f/4, multiple 300-second exposures, 29.25 hours total

Judge's verdict: "It's the incredible balance of detail at different distances that makes this a truly impressive image. Dozens of galaxies pepper the scene. More are revealed the longer you look. With razor-sharp focus and beautiful bursts of colour, this is a worthy winner of the category." **– Greg Brown** ▶



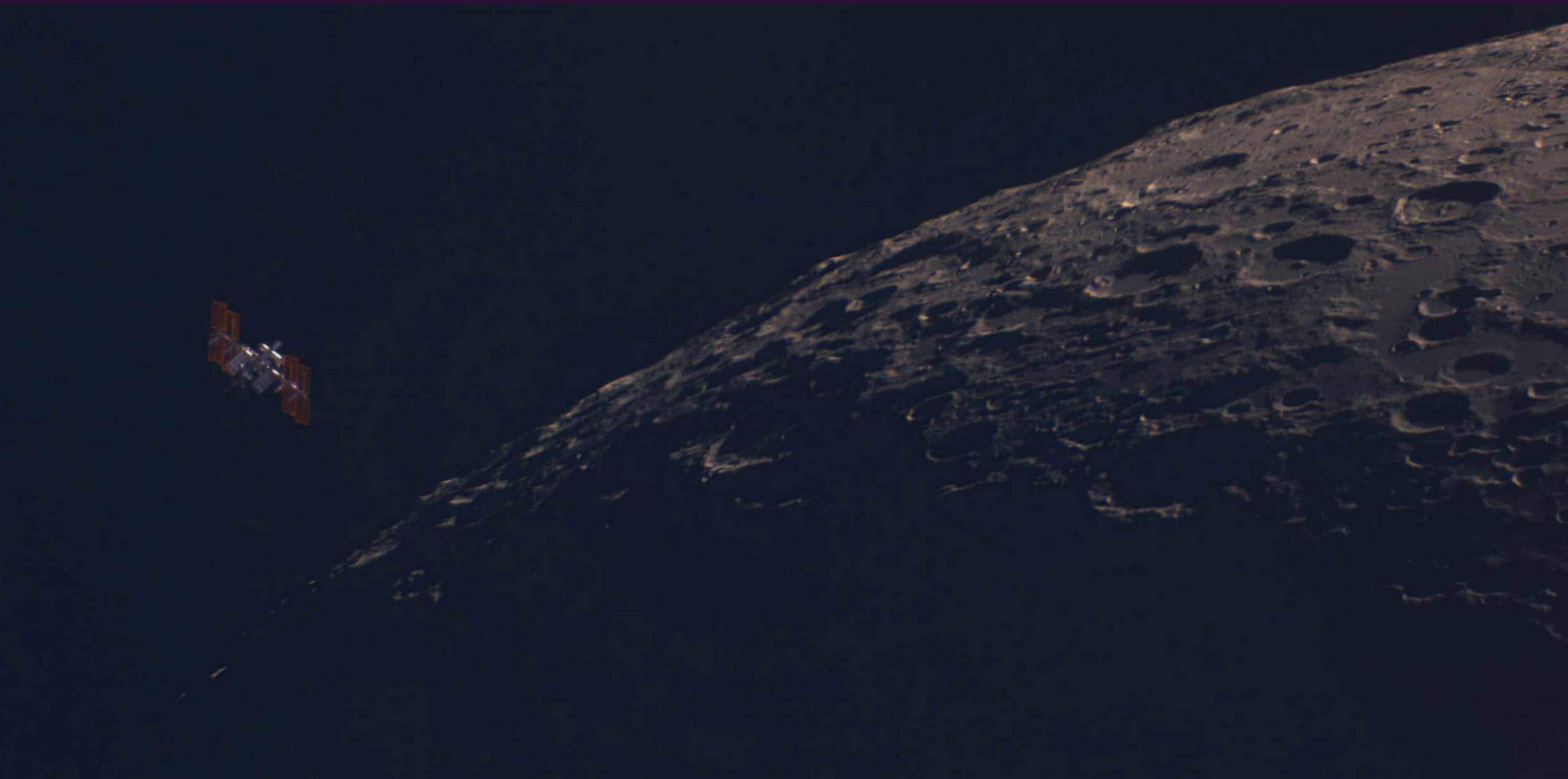


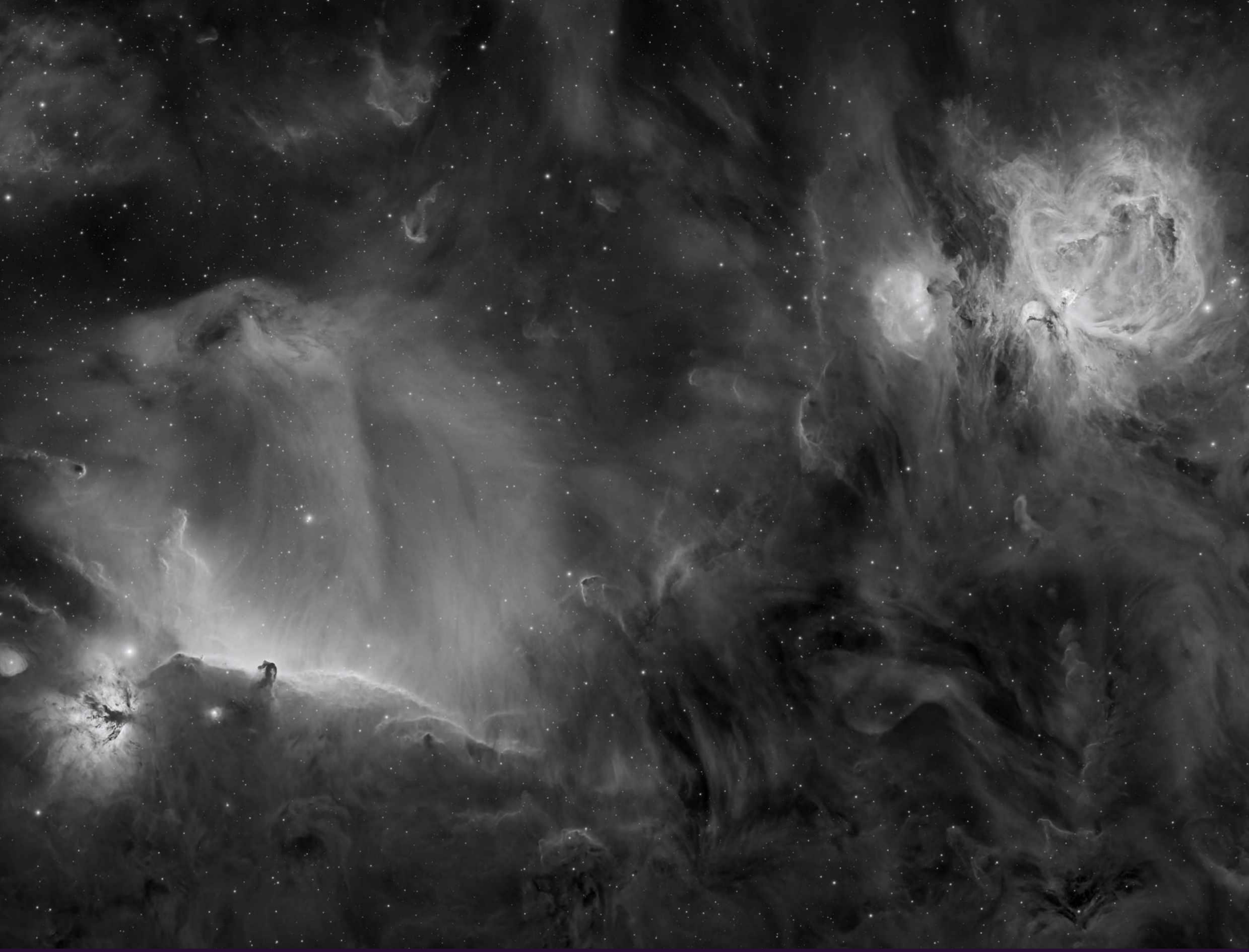
△ Planets, Comets and Asteroids

Comet 12P/Pons–Brooks Taking a Final Bow
Dan Bartlett
Location: June Lake, California, USA
Equipment: Celestron C14Edge HD SCT telescope, HyperStar V4 lens, 10Micron GM2000 HPS mount, ZWO ASI2600MC Pro camera, 712mm f/2, 25x 30-second exposures
Judge's verdict: "This fine cometary image is dramatically composed, and exceptionally crisp and detailed. Its blue tones contrast beautifully with the brilliant orange star nearby. The billowing tail evokes the sense of the comet roaring across the night sky – reminiscent of the fiery trail of the rocket ship in the 1936 film *Flash Gordon*."
– Martin Lewis

▽ People and Space

ISS Lunar Flyby
Tom Williams
Location: Trowbridge, Wiltshire, England
Equipment: Sky-Watcher 400P Go-To Dobsonian telescope, Player One Astronomy Uranus-C (IMX585) camera, 300mm f/15.5, 1.5-millisecond exposure
Judge's verdict: "It's good to be reminded that people are on board the ISS as it traverses the Moon. Soviet cosmonaut Yuri Gagarin made the first space flight in 1961. I wonder if, today, we've become complacent about our presence in space. This image shows us that we are still space explorers and pioneers at the very beginning of our journey. A picture of great hope." **– Alan Sparrow**





△ **ZWO Young Astronomy Photographer of the Year**

Orion, the Horsehead and the Flame in H-Alpha

Daniele Borsari (aged 15)

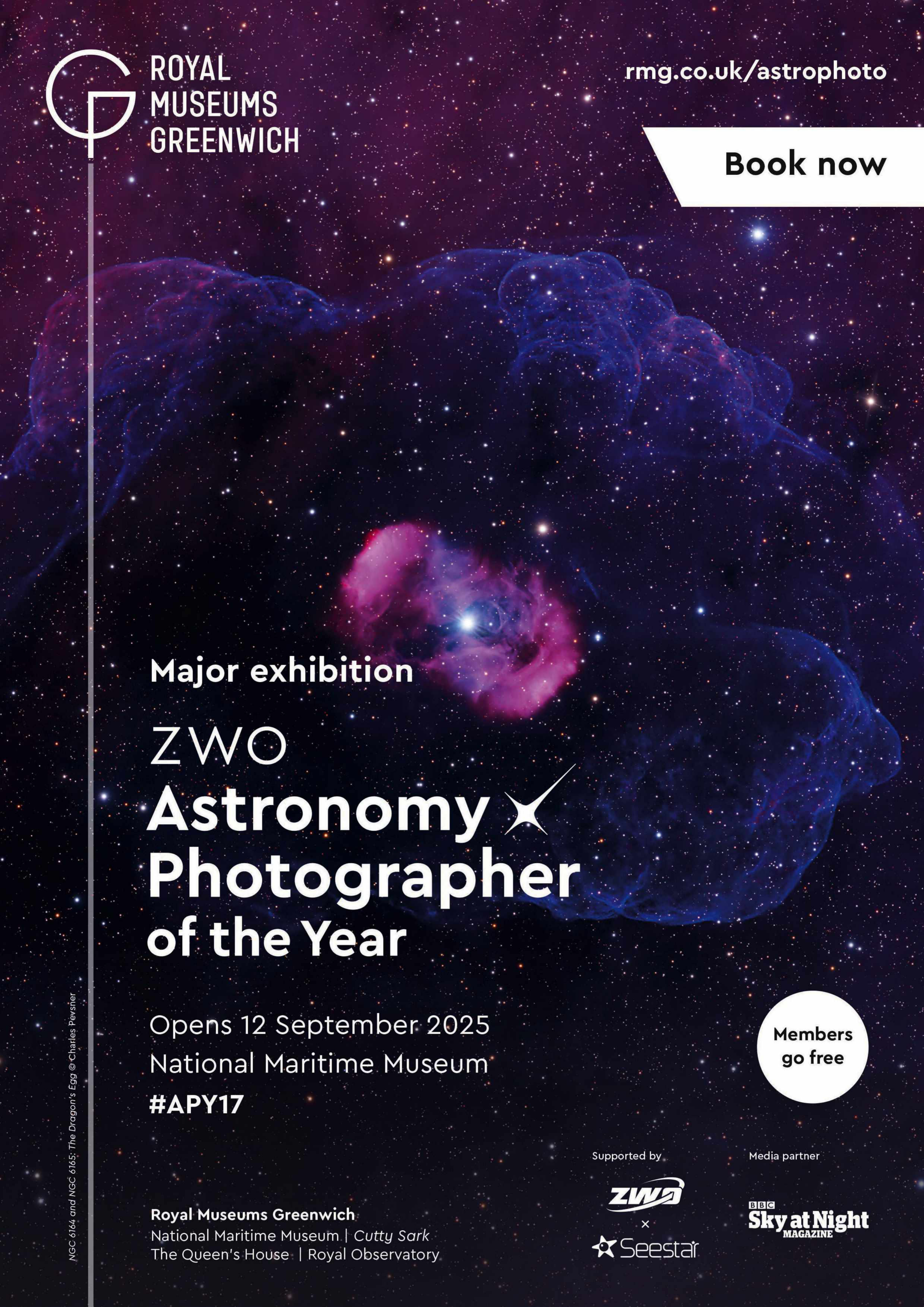
Location: Leffe, Bergamo, Italy
Equipment: Player One Astronomy Ares-M Pro camera, Sky-Watcher HEQ5 Pro mount, Samyang 135mm f/2.0 lens, 135mm f/2.8, 45x 60-second exposures and 262x 300-second exposures, 22 hours 35 minutes total
Judge's verdict: "It never ceases to amaze me how the quality of images in the Young category can rival those in the overall competition – and few demonstrate that more clearly than this one. Choosing black and white over bright colours, and focusing purely on the shapes and contours of the nebulae, is a bold decision that has paid off. The Orion, Horsehead and Flame Nebulae have rarely looked so dynamic, and it's easy to imagine these vast gas clouds roiling and billowing through space." **– Greg Brown**

FREE BONUS CONTENT

You can find a gallery of these and more fantastic images from the 2025 competition at www.skyatnight magazine.com/ bonus-content

The judges

Yuri Beletsky is a professional astronomer and award-winning nightscape photographer based in Chile
Ed Bloomer is Senior Astronomy Manager: Digital & Data at Royal Museums Greenwich
Greg Brown is an astronomer and science communicator within the Astronomy Team at the Royal Observatory, Greenwich
László Francsics is an architect, astrophotographer and Chair of the Hungarian Astrophotographers' Association
Kerry-Ann Lecky Hepburn is an astrophotographer and senior meteorologist for a 24-hour TV station in Canada
Victoria Lane is Senior Curator of Art and Identity at Royal Museums Greenwich
Martin Lewis is an optoelectronics engineer, telescope builder and high-resolution planetary imager
Steve Marsh is Art Editor of *BBC Sky at Night Magazine*
Alan Sparrow is Chair of the UK Picture Editors Guild and Director of the UK Picture Editors Guild Awards
Neal White is Professor of Contemporary Art/ Science at the University of Westminster, where he is a Director of CREAM



NGC 6164 and NGC 6165: The Dragon's Egg © Charles Pevsner

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rmg.co.uk/astrophoto

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ZWO
Astronomy Photographer of the Year

Opens 12 September 2025
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16-PAGE CENTRE PULLOUT

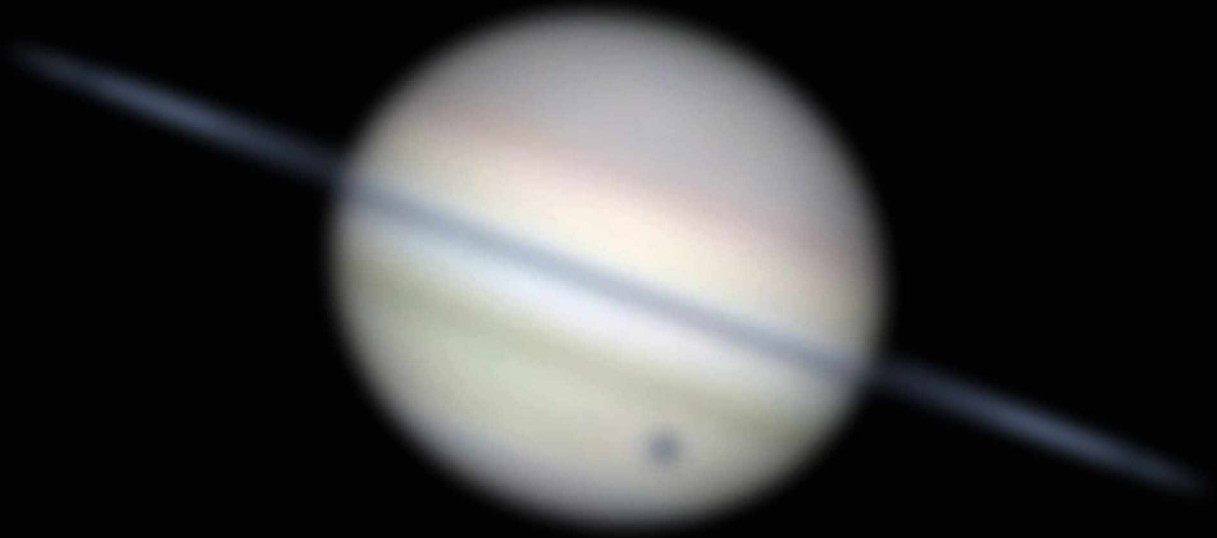
BBC Sky at Night MAGAZINE

The Sky Guide

OCTOBER 2025

LAST CHANCE TRANSITS

Catch Titan crossing Saturn twice this month – but be quick, as these events are coming to an end



PETE LAWRENCE

POWER SHOWER

Orionids are set for a very favourable show this year

GET ON DOWN

Can you find all six of our tough horizon-huggers?

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ 2025's perigee Harvest Moon
- ✦ Ceres at opposition
- ✦ Sheratan in Aries, our Star of the Month
- ✦ Lunar crater Prinz

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

OCTOBER HIGHLIGHTS

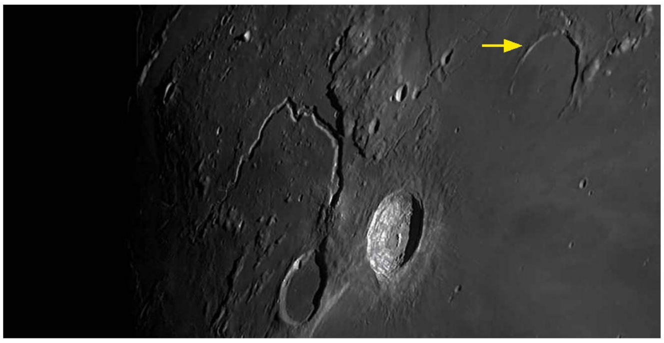
Your guide to the night sky this month

Thursday

2 Dwarf planet Ceres reaches opposition in the constellation of Cetus, shining at mag. +7.6. Find further details on page 47.

Friday ▶

3 Tonight and the night of 17/18 October are good times to look for this month's Moonwatch target, the half-submerged crater Prinz. See page 52 for more details.



◀ Tuesday

7 This morning's full Moon is the closest to the Northern Hemisphere's autumn equinox, making it 2025's Harvest Moon. It's also a perigee full Moon, when the Moon is closest to Earth in its orbit. This occurs at 13:36 BST (12:36 UT) on 8 October.

Wednesday

8 The Harvest Moon and its subsequent gibbous incarnations exhibit the smallest differences in rise times for the year. Yesterday's full Moon rose at 18:25 BST (17:25 UT); today, moonrise is just 15 minutes later at 18:40 BST (17:40 UT).

Thursday

9 If you're quick, you can catch mag. +12.0 comet C/2024 E1 Wierzchoś when it's 0.5° from mag. +3.7 Gamma (γ) Herculis this evening. The Moon will be rising though, so try to grab a view as soon as the sky darkens.

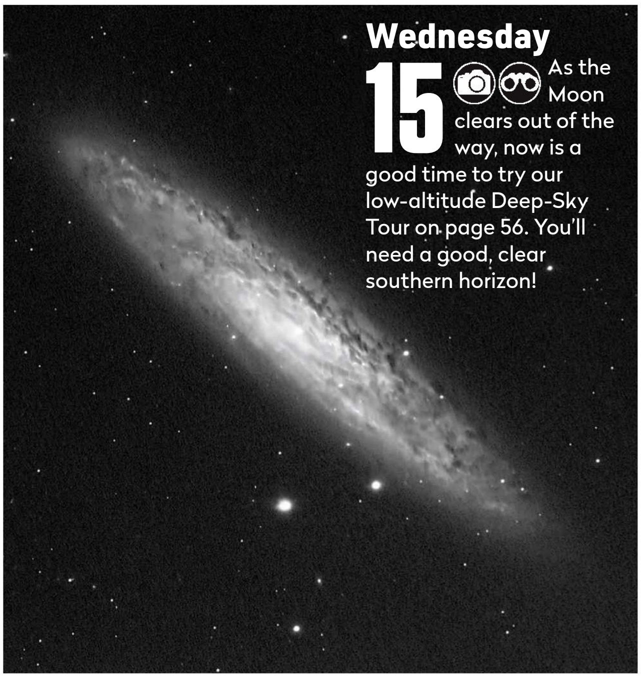
Monday

13 Jupiter appears close to this evening's 47%-lit waning crescent Moon.

Titan is occulted by Saturn at 23:54 BST (22:54 UT).

Tuesday

14 A 36%-lit waning crescent Moon rises around midnight and lies 1.2° north of the centre of M44, the Beehive Cluster.

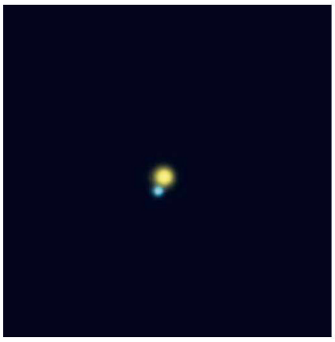


Wednesday

15 As the Moon clears out of the way, now is a good time to try our low-altitude Deep-Sky Tour on page 56. You'll need a good, clear southern horizon!

Sunday ▶

19 A tricky conjunction occurs between mag. +1.5 Mars and mag. –0.1 Mercury this evening, with the planets separated by 2° very low above the southwest horizon shortly after sunset. Be sure the Sun has set before searching with binoculars.



◀ Wednesday

22 Comet C/2025 A6 (Lemmon) is easy to find this evening, located 1.3° from the mag. +2.5 double star Izar (Epsilon (ε) Boötis). Catch this mag. +10.3 comet as soon as the sky darkens after sunset.

Sunday

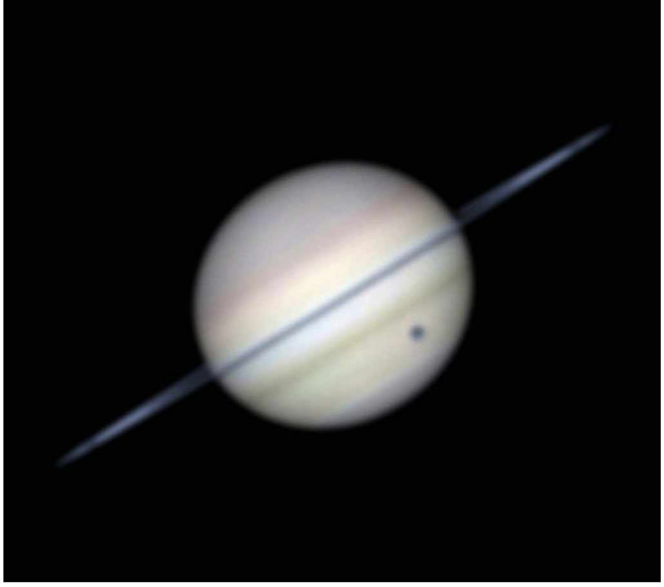
26 The UK's period of daylight savings comes to an end today. At 02:00 BST this morning, the clock reverts to 01:00 UT.

Wednesday

29 Saturn's largest moon Titan is occulted by the planet at 20:38 UT.

Mercury reaches greatest eastern elongation, separated from the Sun by 23.9°. It sets just after the Sun.

PETE LAWRENCE X 9



Monday ▶

6 Between 02:18 BST (01:18 UT) and 05:51 BST (04:51 UT) when Saturn sets, its largest moon Titan is in transit across the planet's disc. See page 46 for more on Titan's interactions with Saturn this month.

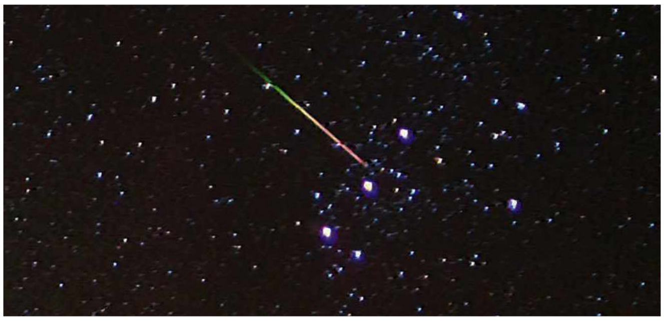
◀ Friday

10 The Moon occults part of the Pleiades open cluster this morning, though the event is truncated by the onset of dawn twilight.

Today is the peak of the (low-rate) Southern Taurid meteor shower.

Thursday ▶

16 Even in October, it's still possible to see the brightest part of the Milky Way visible from the UK – the part that runs through Cygnus. With the Moon out of the way, the skies are nice and dark now too.



◀ Tuesday

21 Peak of the Orionid meteor shower. It should be a good show – see page 47.

Titan transits Saturn from 23:41 BST (22:41 UT).

Thursday

30 At around 22:30 UT tonight (depending on your exact location), the 62%-lit waxing gibbous Moon will occult mag. +3.7 Nashira (Gamma (γ) Capricorni).

Family stargazing

The Harvest Moon is the name given to the full Moon closest to the Northern Hemisphere's autumn equinox. This year, that title goes to the full Moon on 7 October. What makes it special is that, around this time, the Moon rises at nearly the same time each evening – unlike the usual average difference of about 50 minutes. Challenge your young observers to record the Moon rise time each night, and compare the difference from one day to the next. How do their times compare with the 50-minute average?
www.bbc.co.uk/cbeebies/shows/stargazing

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/stargazing-top-tips** to learn how to stargaze in 12 easy steps and **bit.ly/choose-first-telescope** for advice on choosing your first scope

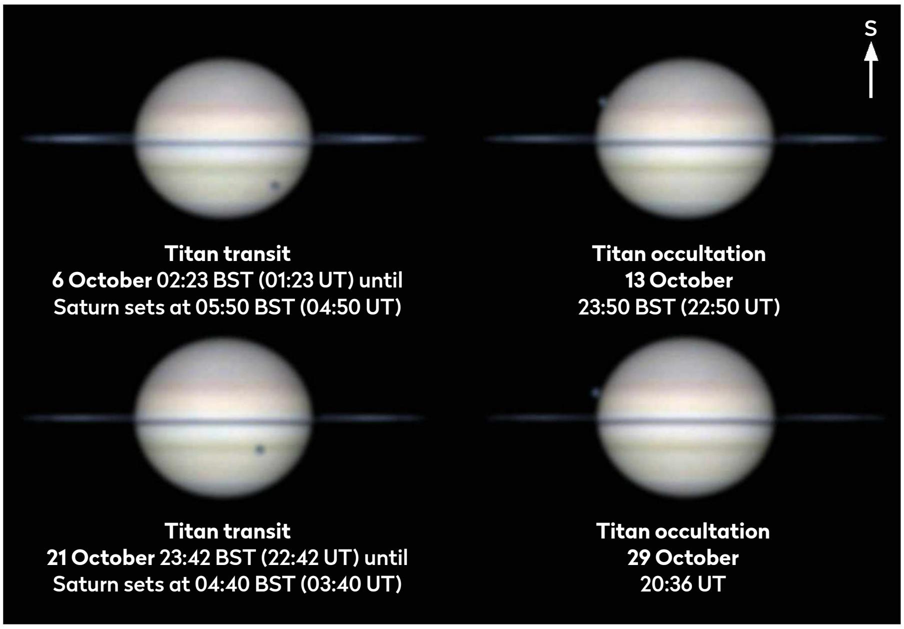
THE BIG THREE

The top sights to observe or image this month

DON'T MISS

Titan events

BEST TIME TO SEE: 6, 13, 21 and 29 October at the times shown


S
Titan transit
6 October 02:23 BST (01:23 UT) until
Saturn sets at 05:50 BST (04:50 UT)
Titan occultation
13 October
23:50 BST (22:50 UT)
Titan transit
21 October 23:42 BST (22:42 UT) until
Saturn sets at 04:40 BST (03:40 UT)
Titan occultation
29 October
20:36 UT

▲ Saturn's interactions with Titan this month – time is running out to catch them

> *"Saturn's rings are narrowing once more and will reach a minimum tilt angle between 10 November and 7 December"*

With long, dark nights settling in and Saturn favourably positioned in the sky, now's a great time to catch an unusual view of the ringed planet through a telescope. Saturn underwent a ring plane crossing back in March – when its rings appeared edge-on from Earth – but the event went unobserved due to the planet's close proximity to the Sun.

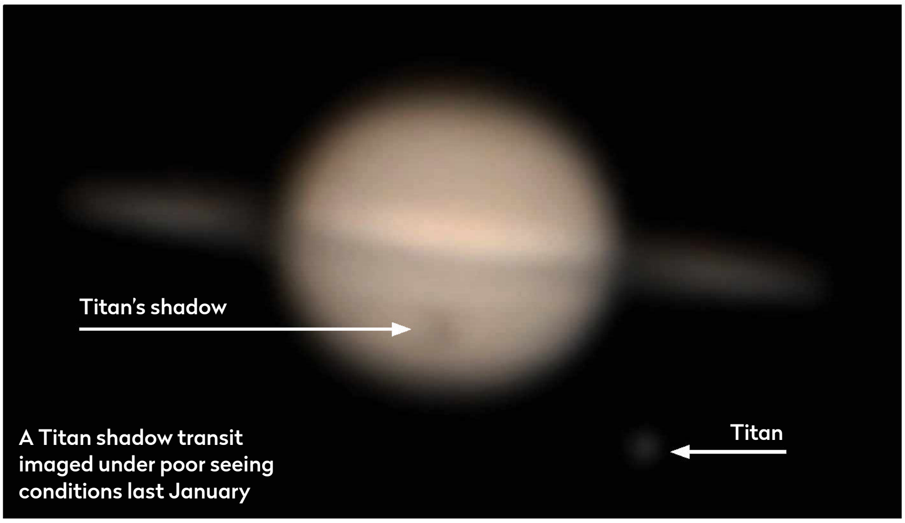
A ring plane crossing occurs when Saturn is near an equinox and tilted so that the Sun aligns with its equatorial plane. Such alignments happen roughly every 15 years and, during them, Saturn also appears virtually edge-on from Earth. Positional jostling between Earth and Saturn means we may see the rings go edge-on either once or three times. Triple ring plane crossings tend to offer better viewing opportunities than single ones.

Saturn's rings are narrowing once more and will reach a minimum tilt angle between 10 November and 7 December, when the planet's southern pole will be tilted towards us by just 0.4°. At this angle, the rings will all but disappear through smaller scopes, though they'll remain just visible as a very thin line through larger instruments.

Saturn's moon Titan also appears to interact with the planet when the tilt angle is small. Several such events will be visible over the next couple of months, but time is running out to see them as Saturn's tilt begins to increase again after the November–December minimum. By February 2026, Titan and its shadow will miss the planet's globe entirely and you'll need to wait another 13 years or so before a new series of Titan transits begin.

Titan will appear to transit Saturn on the morning of 6 October. Starting at 02:23 BST (01:23 UT), the moon slowly creeps in front of Saturn's northern hemisphere, a dark spot against the lighter hues of the planet's atmosphere. It takes Titan 23 minutes to fully cross onto Saturn's disc, remaining there until Saturn sets at around 05:50 BST (04:50 UT). The moon's shadow passes into transit from 05:30 BST (04:30 UT) but, at only 2° altitude, this is unlikely to be seen.

Titan is occulted by Saturn from around 23:50 BST (22:50 UT) on the evening of 13 October, with Saturn setting just as Titan reappears. Then on 21 October from 23:42 BST (22:42 UT), Titan will once again transit Saturn's globe, though this will be truncated by Saturn setting at 04:40 BST (03:40 UT). A final Titan occultation starting at 20:36 UT on the evening of 29 October concludes this month's string of Titan–Saturn interactions.



A Titan shadow transit imaged under poor seeing conditions last January

ALL PICTURES: PETE LAWRENCE

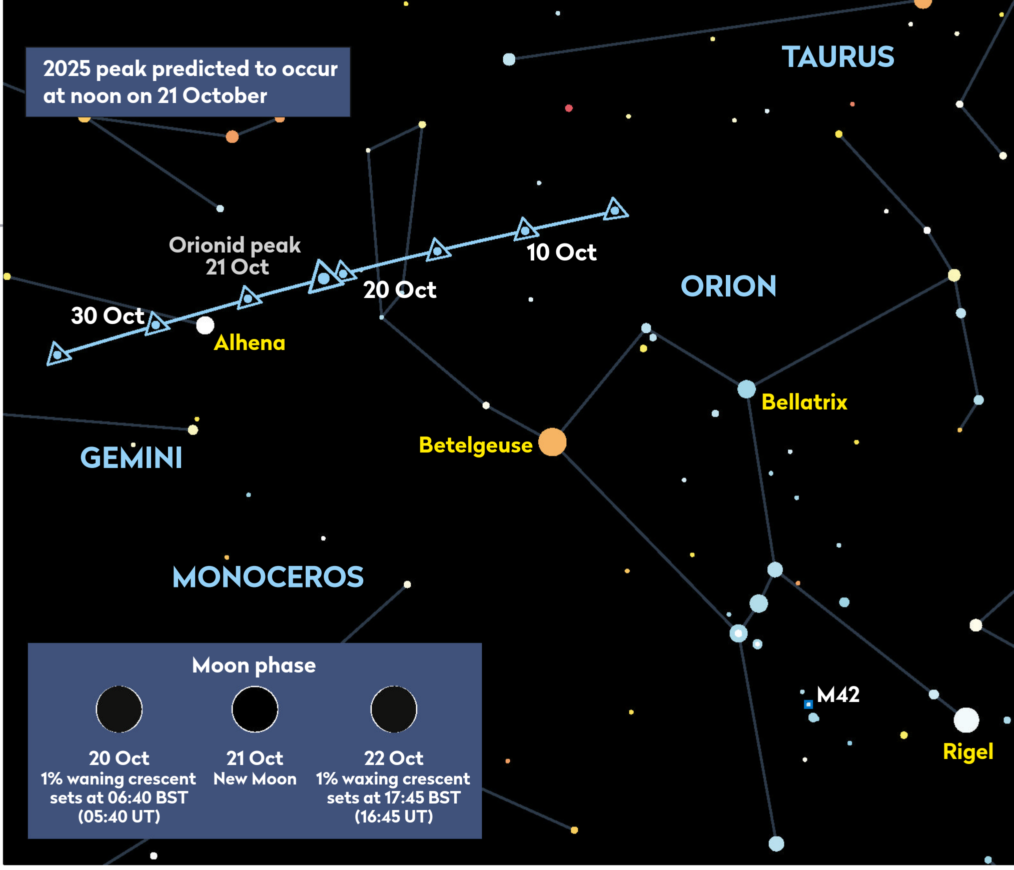
Favourable Orionids

BEST TIME TO SEE: Nights of 19–22 October

The Orionid meteor shower is caused by Earth passing through dust strewn around the orbit of comet 1P/Halley, producing a peak zenithal hourly rate (ZHR) of 20-plus meteors per hour.

Perspective makes meteor showers appear to emanate from a patch of sky referred to as the radiant. In the case of the Orionids, this is located near the star Betelgeuse (Alpha (α) Orionis), the red supergiant marking the northeast corner of Orion's main pattern.

Radiants aren't fixed in the sky; moving from day to day, a shower is active. Some, like August's Perseids, move a fair distance, while others like November's Leonids only move a small amount. Between 2 October and 7 November, when the Orionids are active, its radiant moves roughly from west to east by about 25°. Peak activity occurs when the radiant is located within Orion's borders.


2025 peak predicted to occur at noon on 21 October
TAURUS
Orionid peak 21 Oct
10 Oct
20 Oct
30 Oct
Alhena
ORION
Bellatrix
GEMINI
Betelgeuse
MONOCEROS
M42
Rigel
Moon phase
20 Oct
1% waning crescent
sets at 06:40 BST
(05:40 UT)
21 Oct
New Moon
22 Oct
1% waxing crescent
sets at 17:45 BST
(16:45 UT)

▲ The Orionids peak on 20/21 and 21/22 October – and there's no Moon to interfere

The Moon is new on 21 October, so there will be no moonlight interference. The Orionids peak is expected at 13:00 BST (12:00 UT) on 21 October, which makes the nights of 20/21 and 21/22 October the best for spotting them. If the skies are clear, we'd recommend watching from 21:30 BST (20:30 UT) through to dawn on 19–23 October. Find a dark location away from artificial lights and with a good view of the whole sky. Wrap up warm and get comfortable – a reclining chair or sun lounger are ideal for long meteor watches. Look up at an altitude of around 60°. You can look in any direction, but due south is most interesting.

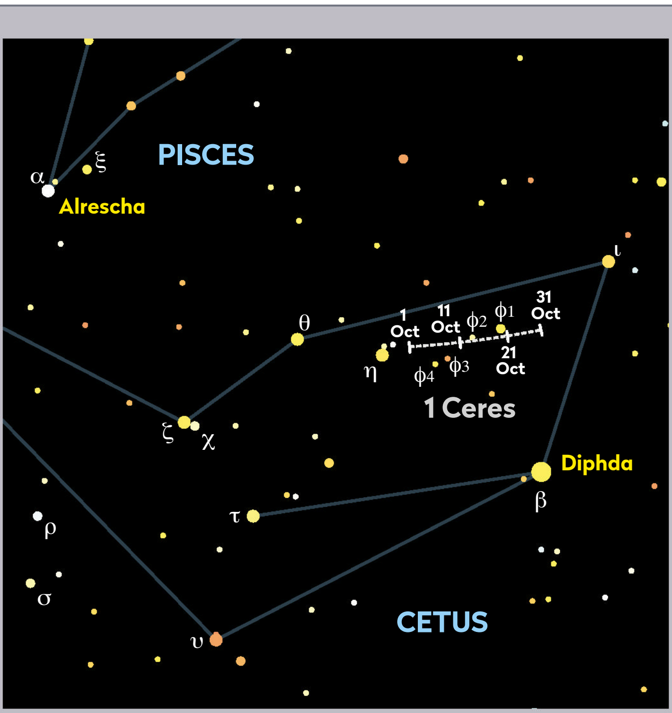
Ceres at opposition

BEST TIME TO SEE: 1–5 and 14–31 October

Dwarf planet Ceres reaches opposition in the constellation of Cetus on 2 October. Cetus is well positioned this month, reaching its highest point at: 01:30 BST (00:30 UT) on 1 October; 00:30 BST (23:30 UT) on 15 October; and 22:30 UT on 31 October. Starting the month at mag. +7.5 and fading only slightly to mag. +7.9 by the end, Ceres is a viable binocular target, and small telescopes and smart scopes will have no trouble picking it up.

The key stars that will help you navigate to Ceres are mag. +3.4 Eta (η) Ceti and mag. +4.8 Phi^1 (ϕ^1) Ceti. On 1 October, Ceres lies 2° to the west-northwest of Eta Ceti. It then tracks west in a gentle south-pointing arc, passing just 4 arcminutes south of mag. +5.2 Phi^2 (ϕ^2) Ceti on the night of 12/13 October. At mag. +7.7, it passes 20 arcminutes south of Phi^1 Ceti on the nights of 19/20 and 20/21 October.

Ceres is a large body measuring 939km across and can reach mag. +6.7 during favourable oppositions. Observing it is straightforward: record the star field over several nights and then compare your images. The object that shifts position between frames is likely to be Ceres.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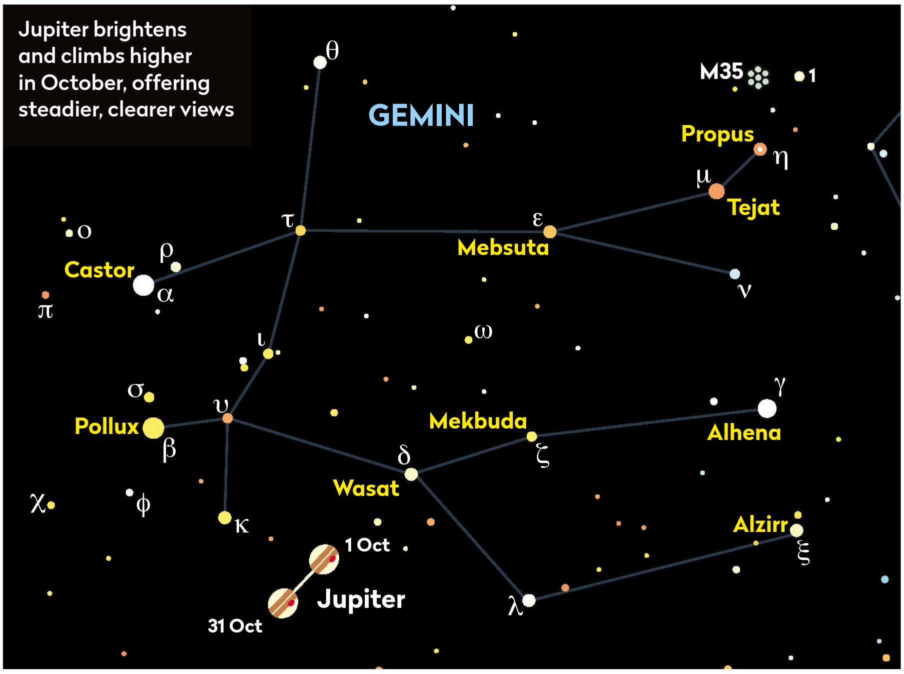
CETUS

▲ Ceres reaches opposition on 2 October. Track the dwarf planet as it drifts west in Cetus, shining with a brightness similar to Neptune's

THE PLANETS Our celestial neighbourhood in October

PICK OF THE MONTH


Jupiter brightens and climbs higher in October, offering steadier, clearer views

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Alzirr
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1 Oct
Jupiter
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31 Oct

Jupiter

Best time to see: 31 October, 05:15 UT
Altitude: 58°
Location: Gemini
Direction: South
Features: Complex atmosphere, moons
Recommended equipment:
100mm or larger

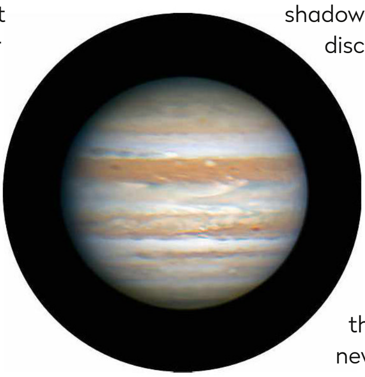
Jupiter skips opposition in 2025. Its last opposition occurred on 7 December 2024, and the next will take place on 10 January 2026. This gap is a normal part of the planet's roughly 13-month opposition cycle. The good news is that this currently puts the planet in an excellent position for observation and imaging.

Jupiter is in Gemini at present, near the stars Castor (Alpha (α) Geminorum) and Pollux (Beta (β) Geminorum), a spot that Mars passed through last spring. The planet is bright at the moment, shining at mag. –2.0 at the start of October and brightening slightly to mag. –2.2 by the end of the month.

Last season saw some interesting atmospheric events taking place, one being the return of the North Temperate Belt (NTB), a dark, narrow belt located just north of the North Equatorial Belt (NEB) in the North Temperate Zone (NTZ). The South Equatorial Belt (SEB), which is famous for being the home of the persistent storm known as the Great Red Spot (GRS), also shows lots of turbulent activity.

Jupiter's next equinox arrives in late 2026, when the planet is presented sideways-on to the Sun, the Sun being on Jupiter's equatorial plane. But the effects begin earlier: by late 2025, moon Callisto will be able to show transits and shadow transits across Jupiter's disc, among other events.

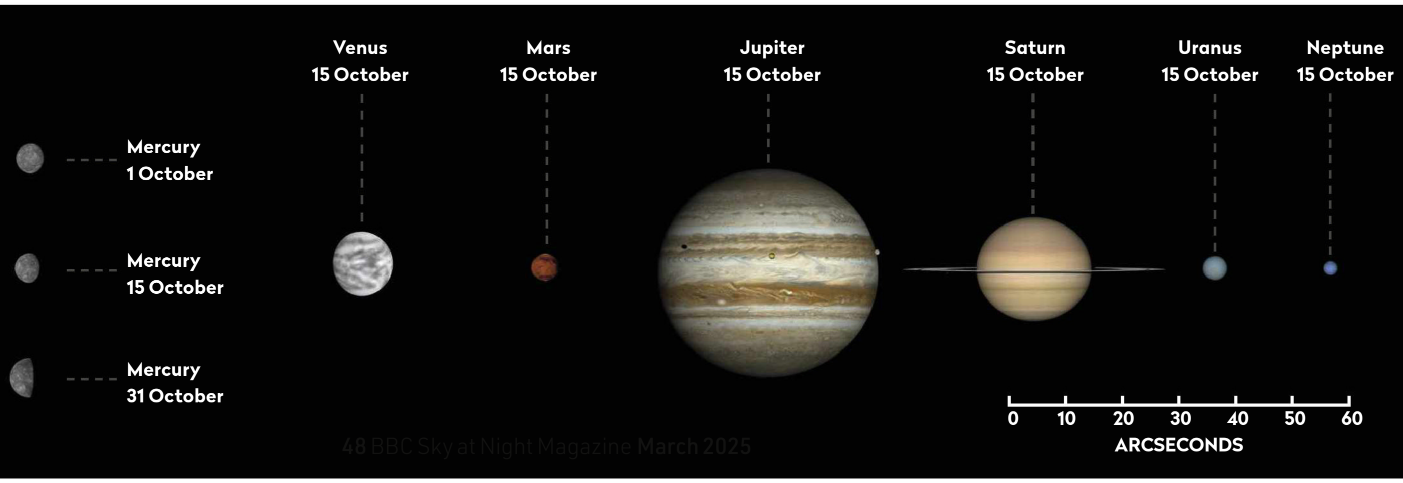
At the very end of the month, Jupiter reaches its highest UK altitude under truly dark conditions. When due south, it will appear 58° above the horizon as seen from the centre of the UK. This is excellent news for planetary observers, because it means Jupiter sits well above the haze and turbulence of lower altitudes.


▲ The planet's complex atmosphere, as imaged last year

PETE LAWRENCE X 2

The planets in October

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope


Venus
15 October
Mars
15 October
Jupiter
15 October
Saturn
15 October
Uranus
15 October
Neptune
15 October
Mercury
1 October
Mercury
15 October
Mercury
31 October
0
10
20
30
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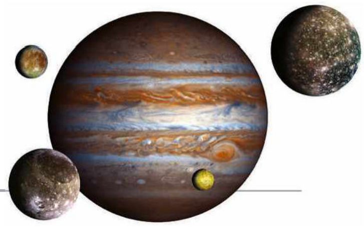
50
60
ARCSECONDS

48 BBC Sky at Night Magazine March 2025



Mercury

Mercury is an evening planet during October. It reaches greatest eastern elongation on 29 October, when it'll be separated from the Sun by 23.9°– but it's poorly placed from the UK, and so probably won't be visible this month.

Venus

Best time to see: 1 October, one hour before sunrise
Altitude: 11°
Location: Leo
Direction: East

The position of morning planet Venus worsens throughout October as it creeps nearer the Sun. On 1 October, Venus rises 2 hours and 20 minutes before sunrise, a mag. –3.8 beacon visible above the eastern horizon in the dawn twilight. On the morning of 19 October, a 4%-lit waning crescent Moon sits 6° west of Venus. By the end of the month, Venus rises 1 hour and 37 minutes before the Sun.

Mars

Mars is currently an evening planet, but it's not particularly easy to see. On 19 October, it sits 2° north of Mercury – but both planets are very poorly positioned for UK observing.

Saturn

Best time to see: 1 October, 00:30 BST (23:30 UT)
Altitude: 34°
Location: Aquarius
Direction: South

Saturn is well positioned after its opposition on 21 September. On 1 October, it's in Aquarius, but only just – a mere 2 arcminutes further north and it would be in Pisces. It reinforces Aquarius as its home throughout October, moving slightly west-southwest over the month.

On 1 October, it's located just 3° from dim Neptune. At 02:00 BST (01:00 UT) on 6 October, a 98%-lit waxing gibbous Moon sits 2.7° north-northwest of Saturn. Saturn's magnitude dips slightly over the course of the month, from +0.2 on 1 October to +0.4 on 31 October.

Uranus

Best time to see: 31 October, 01:25 UT
Altitude: 57°
Location: Taurus
Direction: South

Uranus will reach opposition on 21 November and the planet is currently well placed for observation ahead of this. Shining at mag. +5.6, Uranus is positioned 4.5° south of the beautiful Pleiades open cluster on 1 October. As the planet is a slow mover, this position is held throughout the month, offering a chance for a widefield image of Uranus and the Pleiades together. At mag. +5.6, it is theoretically possible to see Uranus from a dark-sky location.

Neptune

Best time to see: 1 October, 00:35 BST (23:35 UT)
Altitude: 36°
Location: Pisces
Direction: South

Appearing in the same part of the sky as Saturn, Neptune last reached opposition just a couple of days after the ringed planet, on 23 September. As a result, it's well placed for viewing, reaching a peak altitude of 36° when due south. Shining at mag. +7.8, you'll need at least binoculars to spot Neptune, which currently sits just southeast of the Circlet asterism in Pisces.

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Print planet observing forms
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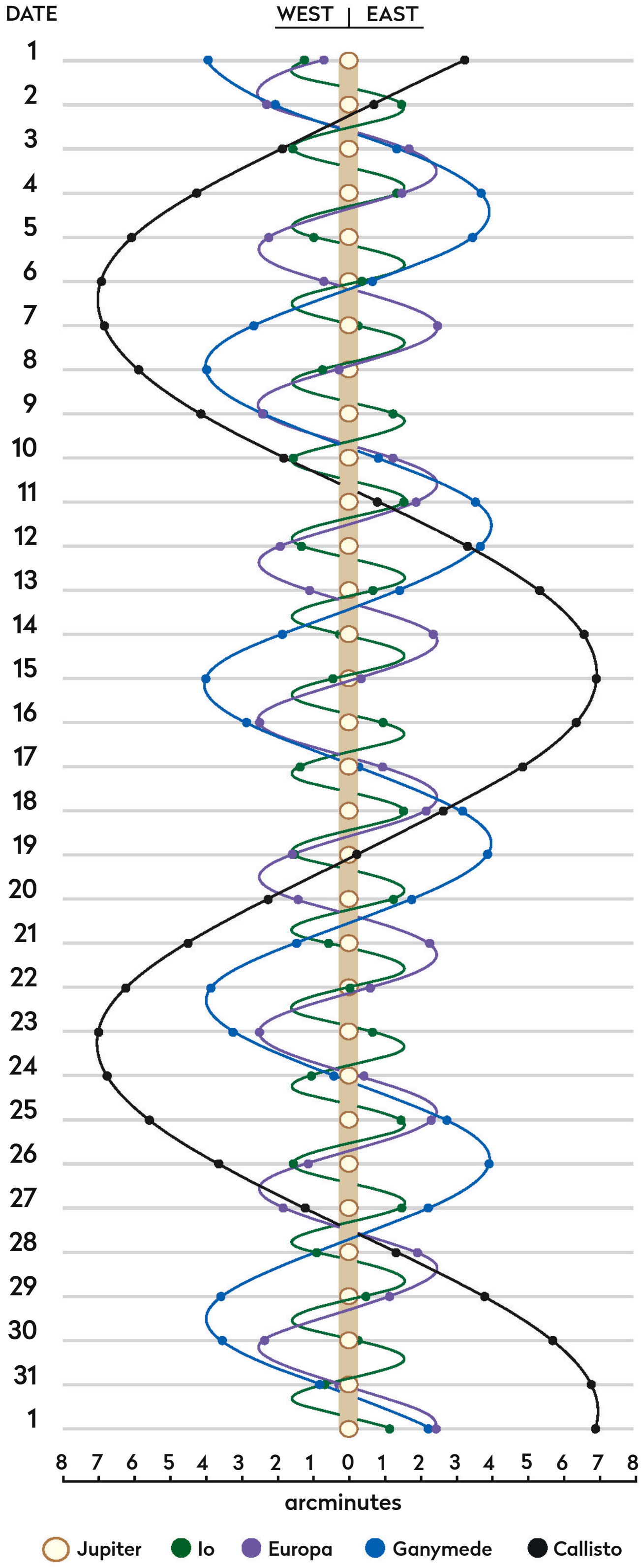
JUPITER'S MOONS: OCTOBER

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – OCTOBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

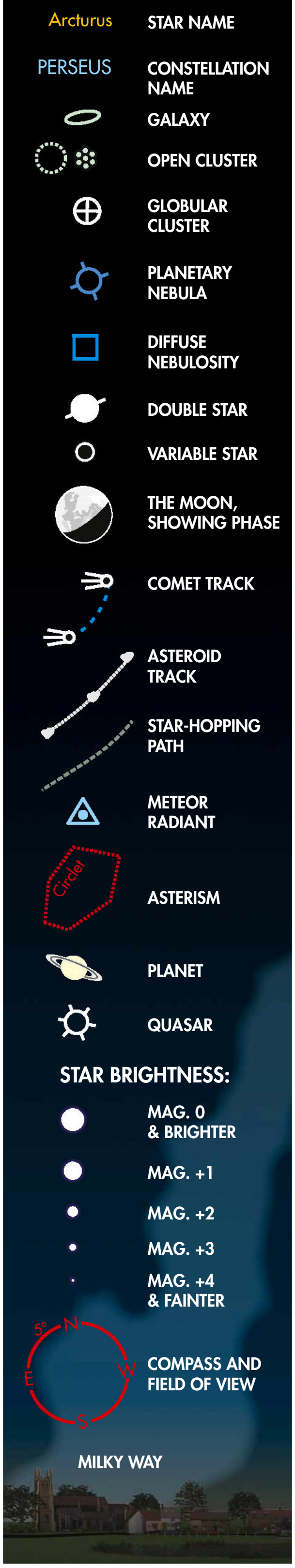

Arcturus
STAR NAME
PERSEUS
CONSTELLATION NAME
GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
THE MOON, SHOWING PHASE
COMET TRACK
ASTEROID TRACK
STAR-HOPPING PATH
METEOR RADIANT
Circlet
ASTERISM
PLANET
QUASAR
STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER
5°
N
E
W
S
COMPASS AND FIELD OF VIEW
MILKY WAY

CHART: PETE LAWRENCE

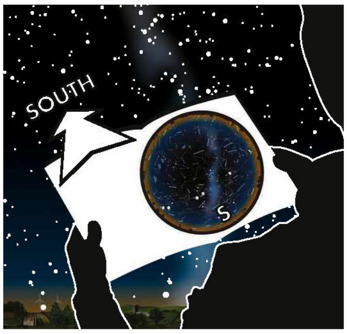
When to use this chart

1 October at 01:00 BST
15 October at 00:00 BST
31 October at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in October*

Date	Sunrise	Sunset
1 Oct 2025	07:11 BST	18:46 BST
11 Oct 2025	07:29 BST	18:22 BST
21 Oct 2025	07:48 BST	17:59 BST
31 Oct 2025	07:07 UT	16:39 UT

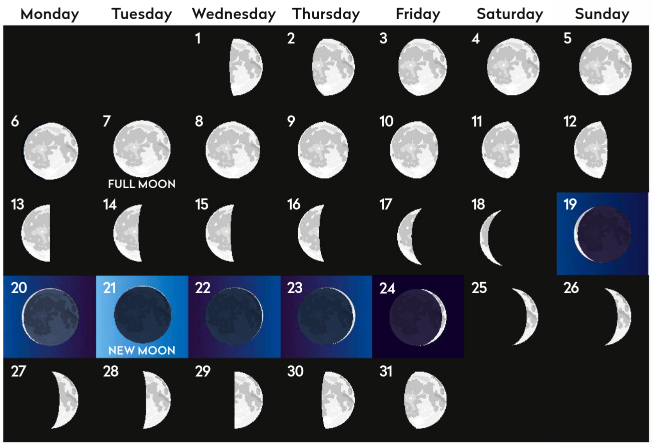
Moonrise in October*

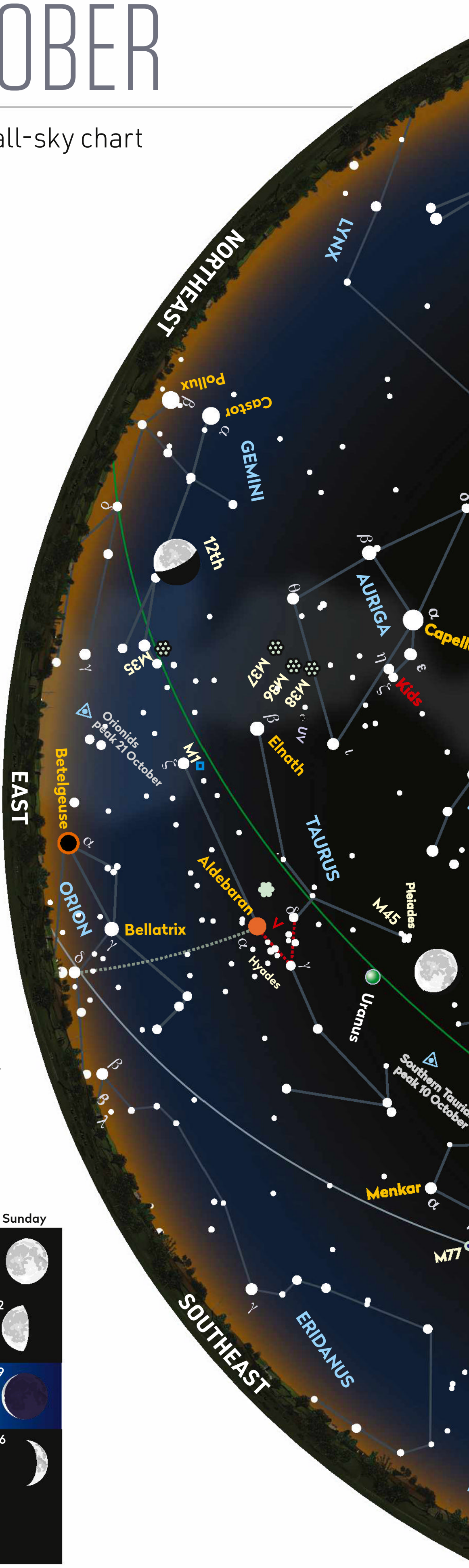
Moonrise times

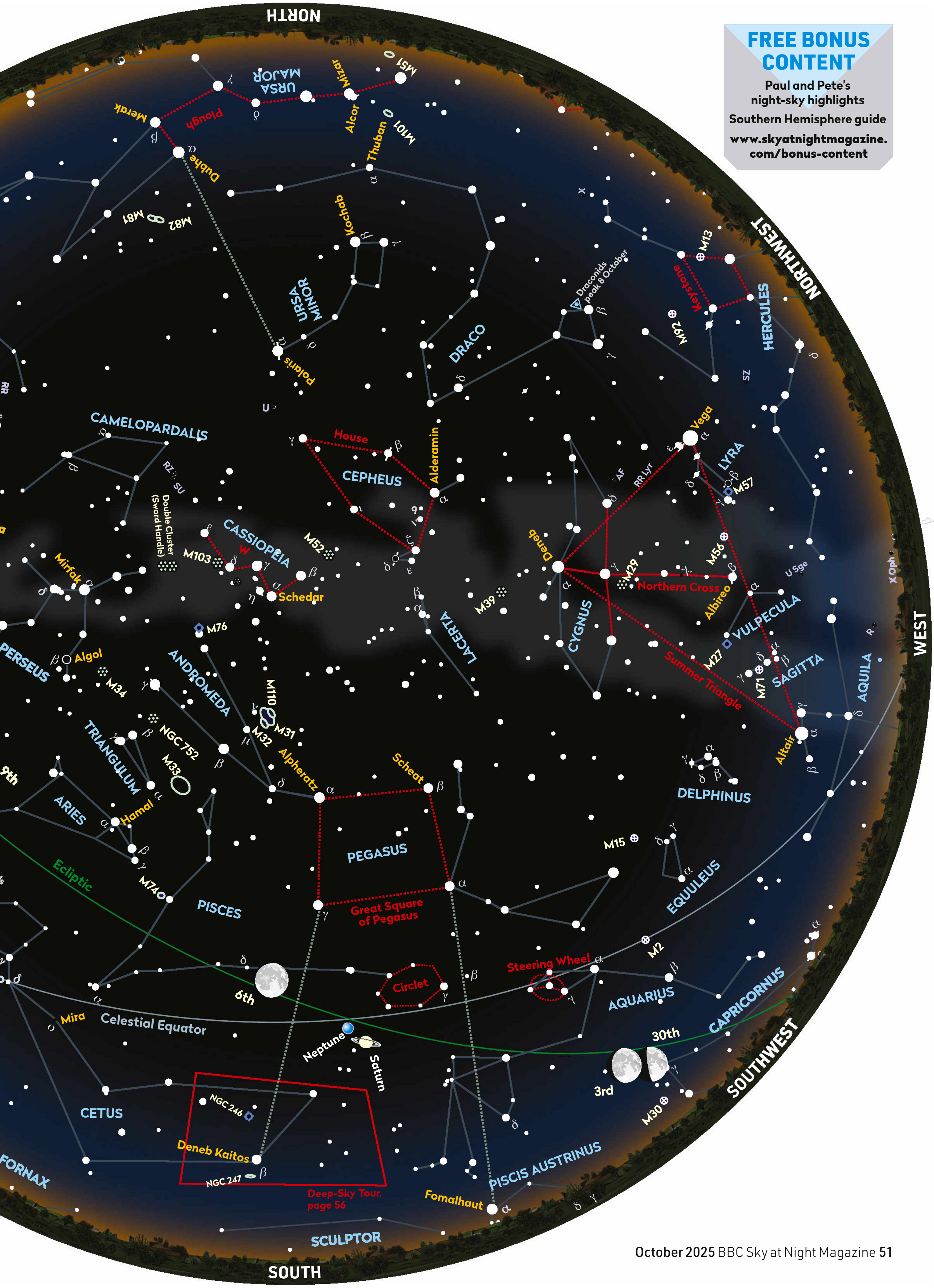
1 Oct 2025, 17:04 BST
5 Oct 2025, 17:59 BST
9 Oct 2025, 18:54 BST
13 Oct 2025, 22:38 BST
17 Oct 2025, 02:51 BST
21 Oct 2025, 07:52 BST
25 Oct 2025, 12:50 BST
29 Oct 2025, 14:27 UT

*Times correct for the centre of the UK

Lunar phases in October




NORTHEAST
LYNX
Pollux
β
Castor
α
GEMINI
δ
12th
β
θ
AURIGA
α
Capell
η
ε
ζ
Kids
γ
M35
M37
M36
M38
β
UV
ι
Elnath
Orionids peak 21 October
ζ
M1
EAST
Betelgeuse
α
TAURUS
ORION
Aldebaran
M45
Pleiades
Bellatrix
γ
δ
δ
α
Hyades
γ
Uranus
β
β
λ
Southern Taurids peak 10 October
Menkar
α
M77
γ
SOUTHEAST
ERIDANUS


NORTH
URSA MAJOR
Merak
Plough
Dubhe
Mizar
Alcor
M51
M101
Thuban
M81
M82
Kochab
URSA MINOR
Polaris
DRACO
Draconids peak 8 October
M13
Keystone
M92
HERCULES
NORTHWEST
SZ
Vega
LYRA
M57
CAMELOPARDALIS
RZ
SU
Double Cluster (Sword Handle)
House
CEPHEUS
Alderamin
AF
RR Lyr
Deneb
M56
M29
Northern Cross
Albireo
U Sge
X Oph
WEST
CASSIOPEIA
W
M52
M103
Schedar
Mirfak
M39
CYGNUS
LACERTA
VULPECULA
M27
M71
SAGITTA
AQUILA
Summer Triangle
Altair
M76
PERSEUS
Algol
M34
ANDROMEDA
M110
M31
M32
NGC 752
TRIANGULUM
M33
Alpheratz
Scheat
DELPHINUS
9th
ARIES
Hamal
PEGASUS
M15
Ecliptic
M74
PISCES
Great Square of Pegasus
EQUULEUS
M2
Steering Wheel
Circlet
6th
AQUARIUS
CAPRICORNUS
Mira
Celestial Equator
Neptune
Saturn
30th
3rd
SOUTHWEST
CETUS
NGC 246
M30
Deneb Kaitos
NGC 247
FORNAX
Deep-Sky Tour, page 56
Fomalhaut
PISCIS AUSTRINUS
SCULPTOR
SOUTH

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Paul and Pete's night-sky highlights

Southern Hemisphere guide

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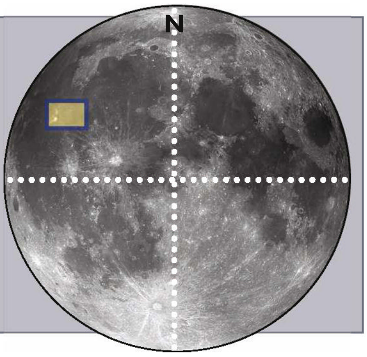
MOONWATCH

October's top lunar feature to observe

Prinz

Type: Crater
Size: 48km
Longitude/latitude: 44.1° W, 25.5° N
Age: 3.8–3.9 billion years
Best time to see: Four days after first quarter (3 October and 1 November) or three days after last quarter (17–18 October)
Minimum equipment: 50mm telescope



Prinz is an interesting, incomplete crater you'll find near bright **Aristarchus**, the brightest large crater visible on the Earth-facing side of the Moon. Unlike sharp and relatively youthful-looking Aristarchus, which is less than 1.1 billion years old, Prinz is ancient and partially submerged beneath the lava of **Oceanus Procellarum**.

> **Prinz is ancient and partially submerged beneath the lava of Oceanus Procellarum**

Around a third of Prinz's rim to the south and southwest is missing. The remaining rim climbs to around 800 metres in the northeast, a relatively smooth transition that makes it look as if Prinz has tilted and is slipping under the lava. This impression is further enhanced by the external ramparts, which are very noticeable around the east, northeast and north but missing around the rest of the rim.

The crater's floor is relatively flat, pockmarked by a handful of 1.2km or smaller craterlets. What remains of the rim is relatively untarnished save for a small collapsed region in the northern section. It appears that there are a couple of small craterlets here, along with an infringement from a tiny crater chain. The maximum width of the chain is around 1km, so could potentially be imaged using a high-resolution imaging setup and a 300mm or larger scope – though the seeing would need to be good and steady.

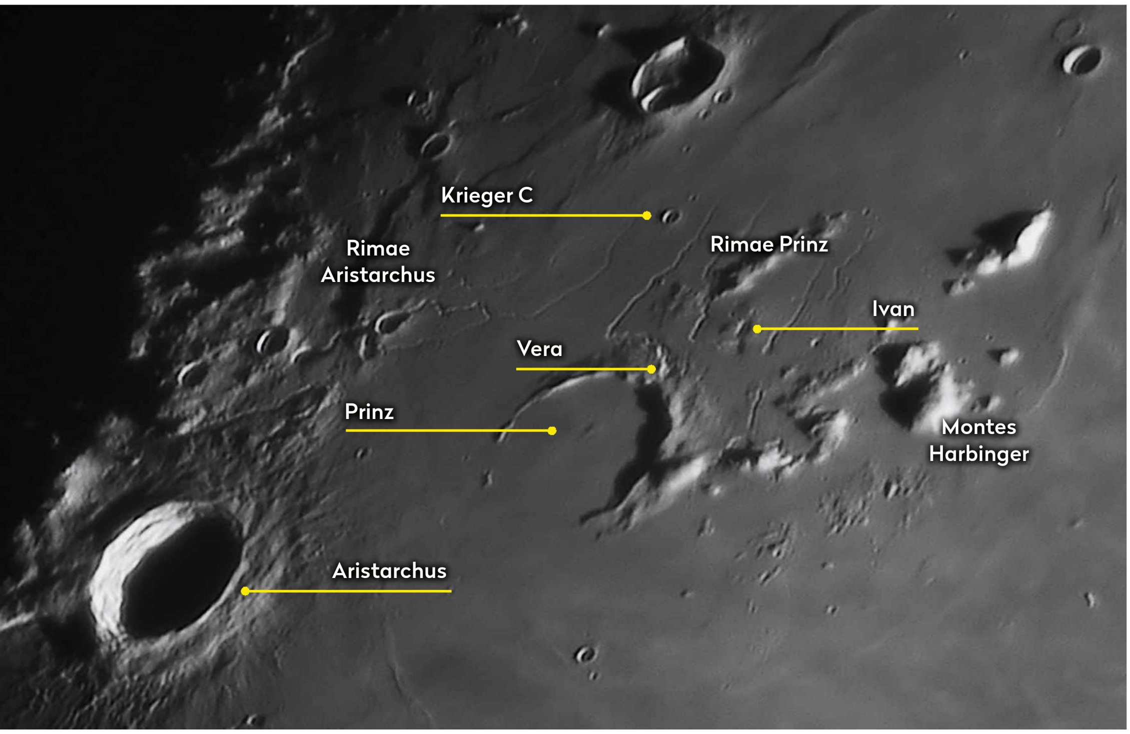
Immediately north of this collapsed section of rim is **Vera**, a 5km teardrop-shaped crater formerly known as **Prinz A**. The region north of Prinz and Vera is littered with rilles collectively known as **Rimae Prinz**, although those further to the west are part of **Rimae Aristarchus**. Vera marks the start of an impressive rille. This meanders with frequent bends directly after leaving Vera, as it heads northwest. It then veers to the west before performing a right-angled turn to the north, eventually passing just to the east of 4.2km **Krieger C**.

The north-running section of the rille is widest in the south, where, after a small 2km-wide bulge, it returns to a fairly consistent width of around 1.4km. The south-to-north section of this rille runs for a distance of around 48km.

Now return to the interrupted northern section of Prinz, drawing a line from it through the centre of Vera. Keep this line going, heading north-northeast, to reach another, marginally wider rille. This starts with a wide triangular region and, like the previous example, heads west before then turning north, travelling for around 42km. Just north of the triangular starting point is a 5km crater depression called **Ivan**, formerly known as **Prinz B**. Another short rille appears to start in the northwest 'corner' of Ivan, arcing almost immediately to the north, before folding back to head east. Just east of Ivan is yet another rille, which begins with a 2.7km round section in the south and travels north from there for around 30km.

As well as the rilles just described – which are fascinating to study when the terminator is close – there are also a number of massifs in the area, forming a mountain range called **Montes Harbinger**. These are clearly visible running north-northeast from Prinz, and rise to a maximum height of around 2km.

▼ To the north and northeast of Prinz are several smaller craters and rilles to explore



PETE LAWRENCE X 3

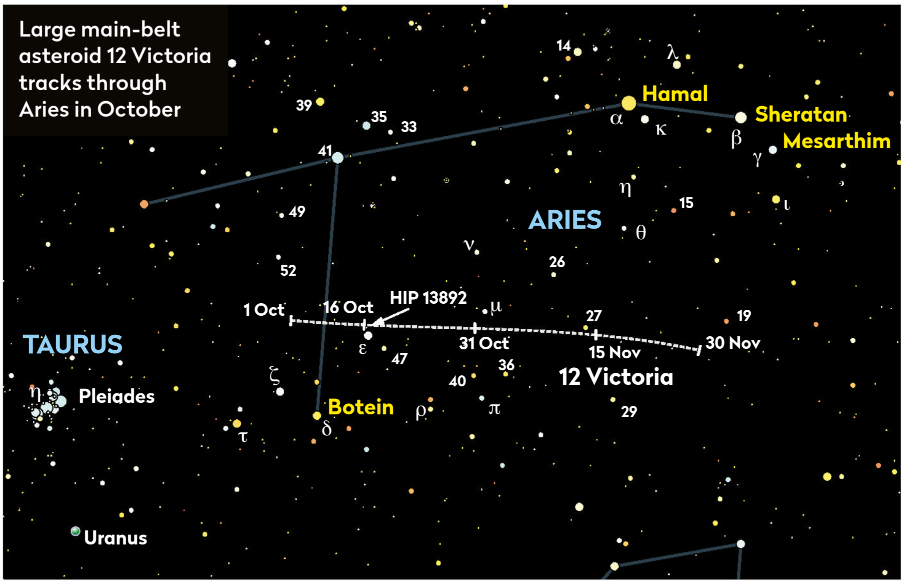
COMETS AND ASTEROIDS

Got a small scope? Follow 12 Victoria as she brightens

The minor planet 12 Victoria reaches opposition on 5 November, when it can be seen shining at mag. +9.9 within the borders of Aries, not too far from mag. +5.7 Mu (μ) Arietis. Victoria remains in Aries throughout October and November, appearing to travel along a straight line from northeast to southwest. You'll need a small telescope to see it.

On 1 October, Victoria will appear to shine at mag. +10.7 and can be found 9° to the west of mag. +2.9 Alcyone (Eta (η) Tauri), the brightest star in the Pleiades. That starting position is just west of the mid-point between mag. +5.4 52 Arietis and mag. +4.8 Zeta (ζ) Arietis.

On 15/16 and 16/17 October, Victoria travels just to the north of mag. +4.6 Epsilon (ε) Arietis. Visually, there's a fainter star, mag. +6.7 HIP 13892, lying 17 arcminutes north of Epsilon. Victoria will skirt this star by around 3 arcminutes just before dawn on 16 October.


Large main-belt asteroid 12 Victoria tracks through Aries in October

Discovered by English astronomer John Russell Hind in 1850, 12 Victoria is named after the Roman goddess of victory, and in honour of Queen Victoria. It's around 120km across and orbits within the main asteroid belt. It's a siliceous or stony (S-type) asteroid that varies in magnitude as seen from Earth, from mag. +8.7 at favourable oppositions to mag. +12.8. Analysis using using radar and speckle interferometry suggests 12 Victoria has an elongated shape and might be a binary asteroid being orbited by an irregularly shaped moon.

STAR OF THE MONTH

Sheratan, the subtle double in Aries

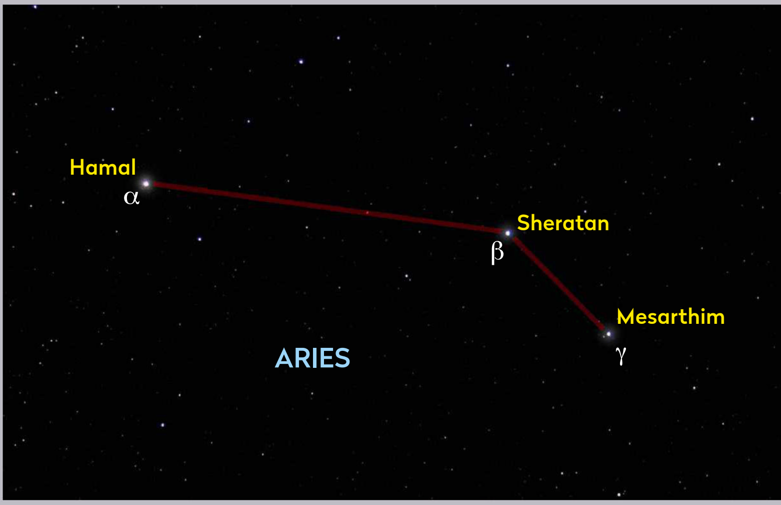
Aries isn't the most dramatic constellation in the night sky, its main pattern consisting of three mid-brightness stars in a bent line. The brightest of the trio, to the east, is mag. +2.0 Hamal (Alpha (α) Arietis) – a star so unexciting and 'normal' it's used as a baseline for comparing others.

The middle star is mag. +2.7 Sheratan (Beta (β) Arietis). Its name means 'the two signs', referring to the time several thousand years ago when Sheratan and mag. +3.8 Mesarthim (Gamma (γ) Arietis) marked the point where the ecliptic and celestial equator intersected. The Sun crossed this position, known as the First Point of Aries, south to north at the Northern Hemisphere's vernal (spring) equinox. Due to precession of Earth's orbit, this location has since shifted into the constellation of Pisces, though it retains the Aries name.

Sheratan lies an estimated 58.4 lightyears from Earth. It's a spectroscopic binary comprising a fast-rotating primary twice as large and massive as the Sun but 21 times more luminous, and a secondary with similar mass to the Sun and a radius 12 per cent larger. Its luminosity is just 30 per cent greater than the Sun's. The secondary's spectral class is G2V (like the Sun), while the primary is a hotter A3V star.

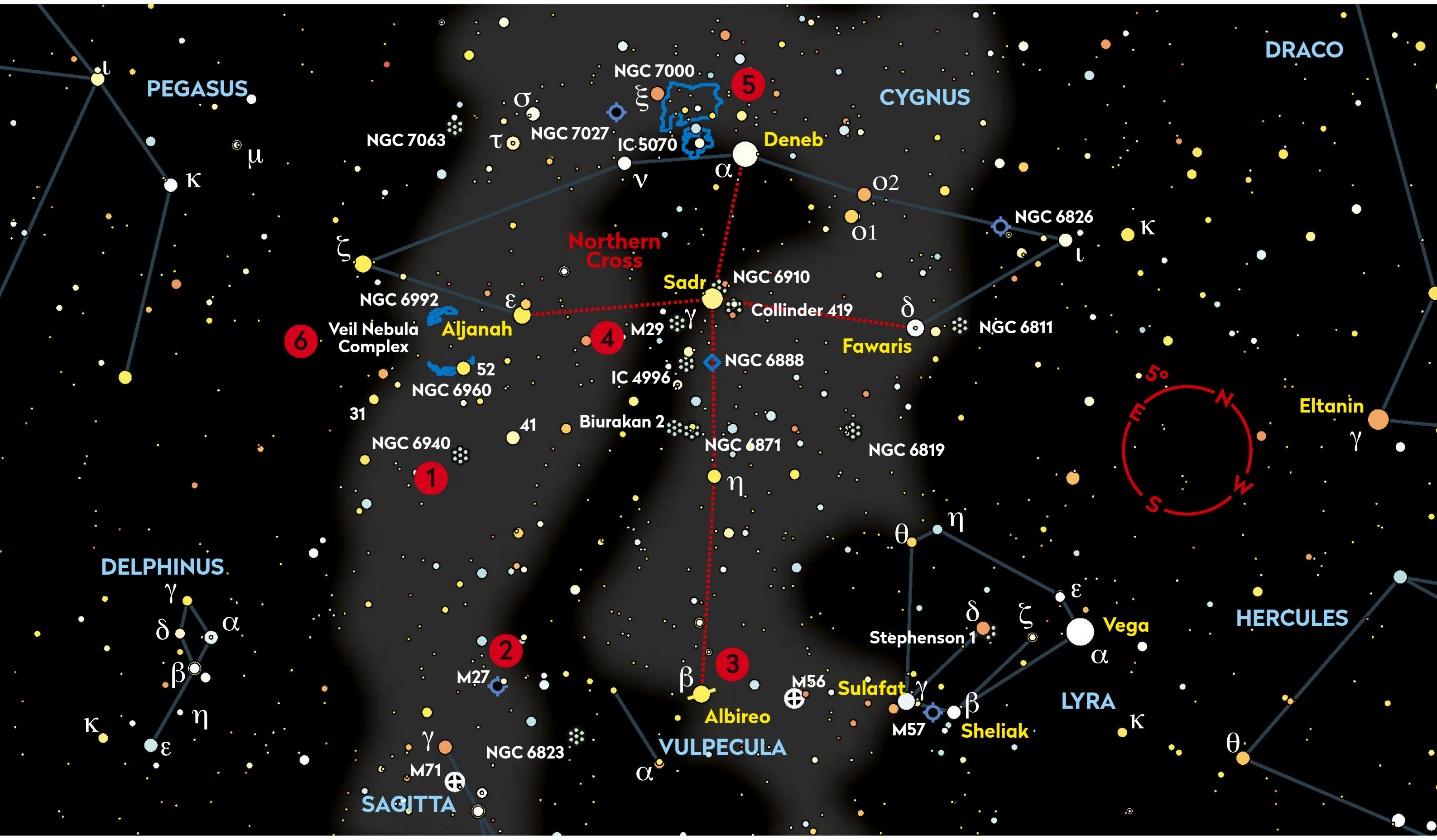
The stars in the Sheratan system orbit one another every 107 days. The system's separation is too small to be measured with a conventional telescope, but the pair have been resolved using the Mark III Stellar Interferometer at the Mount Wilson Observatory in California, USA.

▼ Sheratan, the middle star in Aries's bent line, is actually two stars locked in a tight, 107-day orbit



BINOCULAR TOUR With Steve Tonkin

Your bino beauties this month include an apple core, a continent and a ghostly veil


DRACO
PEGASUS
CYGNUS
NGC 7000
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NGC 7027
IC 5070
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Collinder 419
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NGC 6811
6
Veil Nebula Complex
Aljanah
4
M29
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NGC 6888
52
IC 4996
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31
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Biurakan 2
NGC 6940
NGC 6871
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Stephenson 1
Vega
α
HERCULES
2
M27
3
β
M56
Sulafat
γ
β
Albireo
M57
Sheliak
LYRA
κ
θ
γ
M71
NGC 6823
VULPECULA
α
SAGITTA

1. NGC 6940

10x50 Let's start the tour with open cluster NGC 6940, which deserves to be far better known. To find it, use the chart to identify mag. +4.2 52 Cygni and pan 3.5° to the southwest to an oval patch of light about 0.5° across. You should be able to resolve about eight or so stars within this patch. NGC 6940 is about 2,700 lightyears distant and is thought to be about 800 million years old. ☐ **SEEN IT**

2. The Dumbbell Nebula

10x50 Our next target is the first planetary nebula ever discovered, and the easiest to spot with binoculars from UK latitudes. Put mag. +3.4 Gamma (γ) Sagittae at the south of your field of view and M27, the Dumbbell Nebula, will be just north of centre: a minuscule rectangular glow. You might make out a slight narrowing in the middle that gives the nebula its common name, though in reality it looks more like an apple core than a dumbbell. ☐ **SEEN IT**

PETE LAWRENCE X 3

3. Albireo

10x50 The star at the head of Cygnus, mag. +3.1 Albireo (Beta (β) Cygni) is a very pretty double. The yellow primary has a blue-white mag. +5.1 secondary 34 arcseconds away, making it a good test for the quality of 10x50 binoculars, which you may need to mount to split the pair. Whether it's a true binary or a line-of-sight pairing has been long debated. ☐ **SEEN IT**

4. The Cooling Tower

15x70 M29 lies about 2° south of mag. +2.2 Sadr (Gamma (γ) Cygni). This 7-arcminute misty patch is unremarkable in smaller binoculars, but 15x70s should reveal at least seven ninth-magnitude stars that form its cooling tower shape. The cluster of hot, young blue-white stars lies 6,000 lightyears away and is hurtling towards us at 28km a second. ☐ **SEEN IT**

5. The North America Nebula

10x50 The North America Nebula (NGC 7000) is a large, bright patch of nebulosity with its centre about 3.5° east-southeast of mag. +1.3 Deneb (Alpha (α) Cygni). In ideal conditions, it's visible to the unaided eye as a slightly brighter patch of sky. If you're having trouble detecting it, see if you can make out the dark patch that forms the neighbouring 'Gulf of Mexico', which may be more readily apparent. ☐ **SEEN IT**

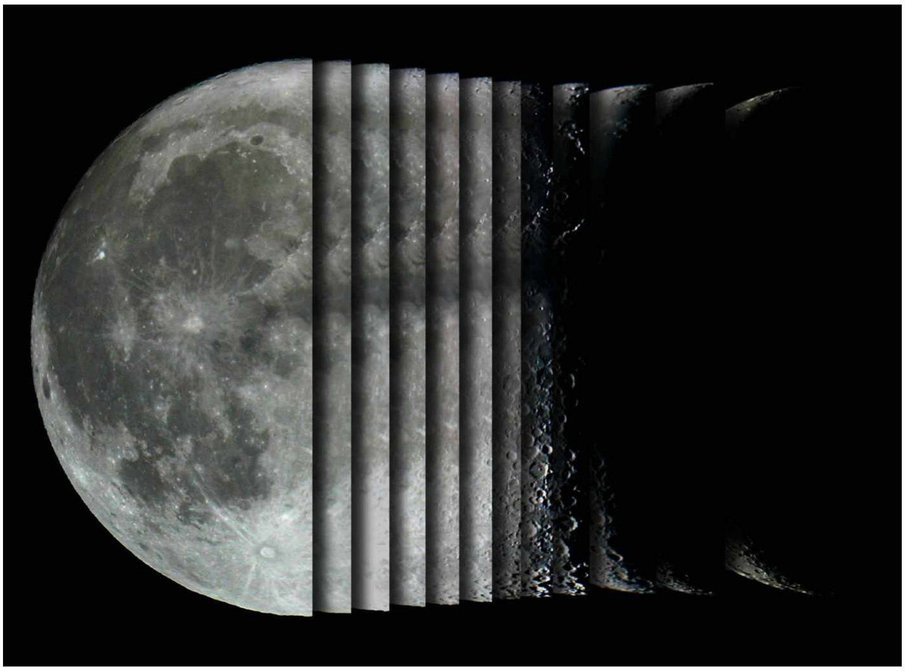
6. The Eastern Veil Nebula

15x70 This month's big challenge is NGC 6992, the brightest part of the Veil Nebula complex, a huge supernova remnant. It's slightly less than 1° south of the centre of a line joining mag. +2.5 Aljanah (Epsilon (ε) Cygni) and mag. +3.2 Zeta (ζ) Cygni. To give yourself the best chance of seeing this ghostly curved glimmer, choose a clear, moonless night and mount your binoculars. Even then, you'll need to use averted vision – and be very patient! ☐ **SEEN IT**

☑ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Make a composite that reveals how the Moon's diameter changes over a lunar cycle



▲ **If you catch enough Moons from the same lunar cycle, you can compile your image strips into a composite – you'll find the change in apparent diameter becomes surprisingly clear**

Supermoons, micromoons and all the in-between Moons occur because the Moon's orbit around Earth (or, more accurately, around the Earth–Moon barycentre) isn't circular but elliptical. This means the Moon's physical distance from Earth varies over the course of its orbit. As a result, its apparent diameter changes too.

Recording these changes is surprisingly easy. All you need is a camera, preferably attached to a telescope or long-focal-length lens, that's able to capture the entire disc of the Moon in one go. The larger the image, the easier it will be to see the effects, but the critical point is you must use the same equipment setup for every image.

The Moon's physical distance also varies slightly between rising, transiting past the south point and setting. That's because when it's rising or setting, it's approximately one Earth radius farther away than when it's due south. The closest approach occurs when it's due south and its altitude matches your latitude in degrees. In this position, the Moon, you and Earth's centre would all lie in a straight line.

This variation in apparent lunar size due to the Moon not being due south is, however, quite small. Even assuming a full Earth radius, the difference would only be around half an arcminute. Typically, the added distance will be less than a full Earth radius and consequently doesn't warrant any real concern. That's good as otherwise you'd need to take each shot when the Moon was at the same cardinal position above the horizon (eg due south). Unpredictable weather, and the fact that some phases can't actually be seen from some locations unless the Sun is up, would make this extremely difficult to achieve.

> **"Recording these changes is easy. All you need is a camera that can capture the entire disc in one go"**

A rising or setting Moon is a little farther away and so a little smaller than when it's higher in the sky

The basic idea of this project is to collect as many images of the Moon as possible throughout a single lunar cycle – and note, it does need to be the same lunar cycle. Tempting though it would be to fill in any gaps (say, when your imaging session gets clouded out) with phase images from a different month, that won't work, as the Moon's phase versus its orbital distance will have shifted slightly.

As a result, there are really two challenges here. The first is to catch enough full-disc images for comparison – a tough ask, given the vagaries of the UK weather! The second is to present your images in such a way that you can directly compare the Moon's diameter.

Here, first orienting each image the same way is useful. With crescents, the position of the cusps helps greatly, but it's a little trickier with gibbous Moons, especially near full Moon. Then you'll need to cut a narrow vertical strip to contain the full diameter and add it to a growing strip chart that will reveal how the Moon's apparent diameter changes over a lunar cycle. Make the strips narrow – that way, any clouded-out shots (that result in gaps in your chart) won't be too obvious.

DEEP-SKY TOUR

Six low-altitude gems that barely peek above the horizon – all the more satisfying to catch!

1 NGC 247

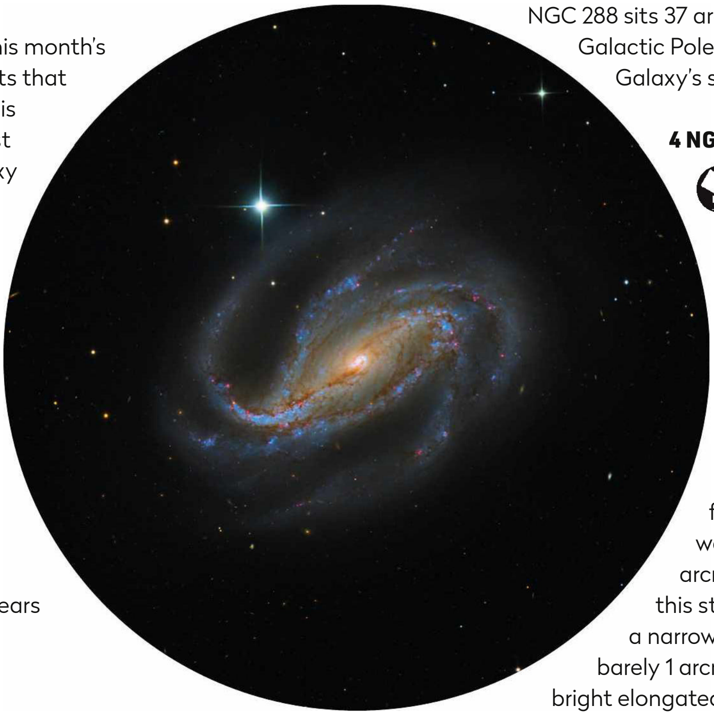
We're going low for this month's tour, looking at objects that are best seen when their region is above the southern horizon. First off is NGC 247, a mag. +9.9 galaxy located 2.9° south and a fraction east of mag. +2.0 Deben Kaitos (Beta (β) Ceti). It's an intermediate spiral, located 11.1 million lightyears away. Despite its fairly bright magnitude rating, it's a large object and so has low surface brightness. A 150mm scope shows it as a narrow, faint and featureless glow, while larger apertures brighten the glow but reveal little more. Through a 250mm scope it appears 15 x 3 arcminutes in size.
☐ **SEEN IT**

2 NGC 253

Heading 4° south of NGC 247 takes you into Sculptor, aka the Silver Dollar Galaxy. Unlike NGC 247, NGC 253 – another intermediate spiral with an integrated magnitude of +7.1 – is rather impressive, despite barely scraping above 10° altitude when due south. Of similar distance to NGC 247, NGC 253's surface brightness is a couple of magnitudes higher – which makes all the difference. Through a 150mm scope it appears 25 x 5 arcminutes in size, while a 300mm scope shows an object over half a degree across, with a 3-arcminute core. Granularity can also be seen, along with a dark dust lane northwest of the core. ☐ **SEEN IT**

3 NGC 288

Now head 1.7° southeast from NGC 253 towards mag. +4.3 Alpha (α) Sculptoris. This is an important star for navigating this low area of sky, though optical assistance will be required to find it from the UK. Globular cluster NGC 288 is a mag. +9.4 object that's quite easy to see through smaller scopes despite its low altitude. It's a fairly loose object lying at a distance of 29,200 lightyears. Appearing slightly flattened through a 250mm scope, and 10 x 8 arcminutes in size, it's easy enough to resolve using a mid- to high-power eyepiece. NGC 288 sits 37 arcminutes from the South Galactic Pole, the southern projection of our Galaxy's spin axis into space. ☐ **SEEN IT**



▲ **You'll need to roll out the big apertures to really make out barred galaxy NGC 613, our fourth target**

4 NGC 613

Our next target is even lower in the sky and best suited to larger apertures. NGC 613 is a barred spiral galaxy lying some 67.5 million lightyears from Earth, with an integrated magnitude of +10.0. To locate it, first centre on Alpha Sculptoris, then slew 7.7° to the east. A convenient mag. +8.4 foreground star shows the way, with the galaxy lying 2.4 arcminutes to the southwest of this star. A 250mm scope shows it as a narrow object 4 arcminutes long and barely 1 arcminute wide, with a small but bright elongated core. With a 300mm scope, you'll see a degree of the core structure as well as hints of the spiral arms. ☐ **SEEN IT**

5 NGC 134

Our final two targets are tricky to see from the UK, but as you're in the region and have hopefully been able to use Alpha Sculptoris to navigate, they're worth a try. Up first is the dimmer of the two, NGC 134, a galaxy thought to have a similar appearance to our own Milky Way. It's 60 million lightyears from Earth and has an apparent magnitude of +10.4. A 250mm scope shows it well, its narrow presentation helping to retain its surface brightness. Appearing 6 x 1 arcminutes in size, you can find it 7.2° southwest of Alpha Sculptoris and 0.5° southeast of mag. +4.8 Eta (η) Sculptoris. This object barely reaches 4° altitude even when due south, so it's a real challenge. ☐ **SEEN IT**

6 NGC 7793

The same low-altitude problem applies to mag. +9.1 NGC 7793. Lying some 12.2 million lightyears away, this is a flocculent spiral galaxy, a type with star-forming regions scattered throughout, giving it a less defined structure and a more mottled texture. Its low surface brightness and very low altitude don't help, but your best starting point is the galaxy's star-like core. Larger apertures may pick out its patchy, flocculent nature, which spans an area 8 x 4 arcminutes across. If you manage to see either of our final two targets, give yourself a pat on the back — they are far-from-easy objects for UK observers.
☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can take you to this month's targets at the touch of a button. Find the Deep-Sky Tour file in our free Bonus Content online.

EQTOUR V1.17
san_deep_sky_tour_ja
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Tour Objects
Altitude
0 Deg
Mag
None
Sync

M79, Globular Cluster
IC418, Spirograph Nebula
NGC 2232, Open Cluster
M42, Great Orion Nebula
M78, Nebula
Meissa, Lambda Orionis

Object RA/DEC: 00:00:00 hr 00:00:00 deg
Object Az/Alt: 74:42:03 deg -12:06:07 deg
Scope RA/DEC: 22:42:19 hr 90:00:00 deg

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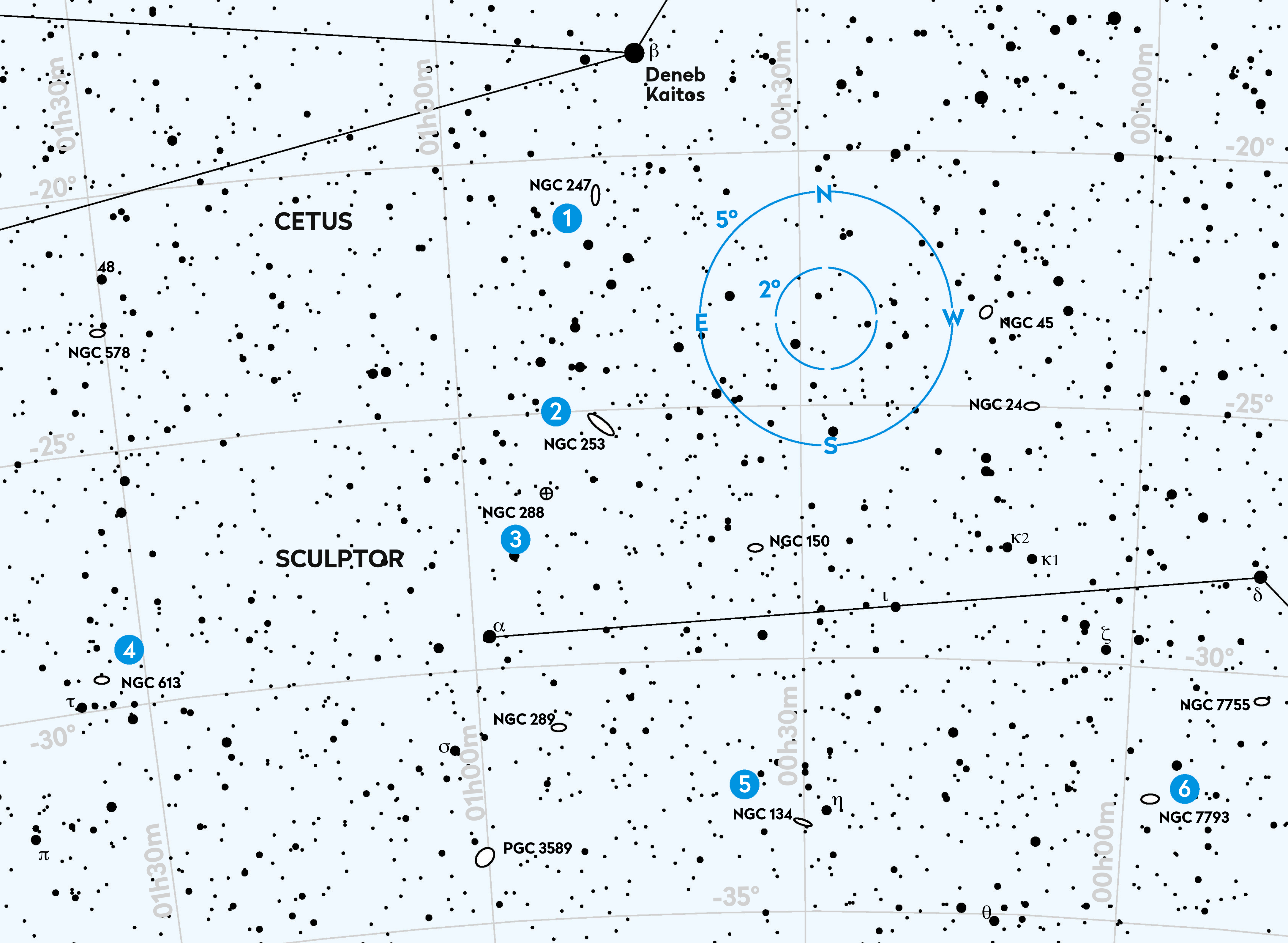
WOLFGANG PROMPER, CCDGUIDE.COM | CHART BY PETE LAWRENCE



β
Deneb Kaitos
CETUS
SCULPTOR
NGC 247
1
NGC 253
2
NGC 288
3
4
NGC 613
5
NGC 134
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NGC 7793
NGC 7755
NGC 578
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PGC 3589
NGC 150
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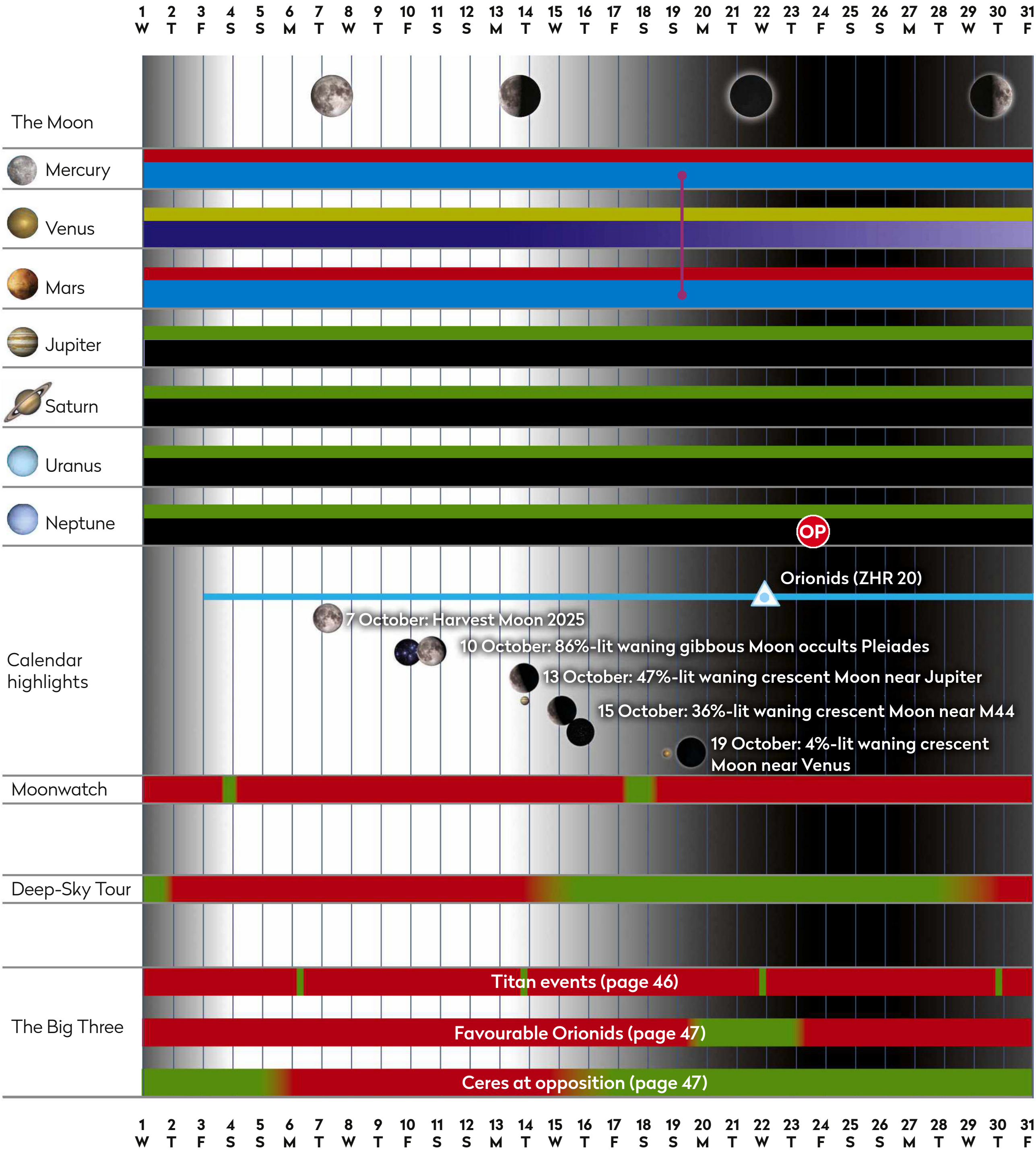
01h30m
01h00m
00h30m
00h00m
-20°
-25°
-30°
-35°

AT A GLANCE

How the Sky Guide events will appear in October



KEY

Observability

🟩 Optimal
🟥 Poor

Best viewed

Morning twilight
Daytime
Evening twilight
Night

Sky brightness during lunar phases

Dark (first quarter)
Light (full Moon)
Dark (last quarter)
Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)
SC Superior conjunction
OP Planet at opposition
△ Meteor radiant peak
Planets in conjunction

Full Moon
First quarter
Last quarter
New Moon

CHART BY PETE LAWRENCE

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Norway is Never the Same Twice

The beauty of Norway doesn't waver between seasons, it simply finds new ways to astonish you. From dreamy summer evenings under the Midnight Sun to the dramatic snow covered landscapes surrounding the fjords during winter, striking scenes are in abundance all year round.

Take a highway to heaven: the Atacama Desert delivers one of Earth's most dazzling views of the cosmos

Stargazing in the Atacama Desert

Becca Marsh tours Chile's high Atacama Desert – home to some of the darkest skies and most advanced astronomical observatories on the planet – and discovers a stargazing destination like no other

We had been driving for most of the day across the rugged terrain of the Atacama to reach our wild camp spot for the night. Shades of rusty orange coated the landscape. Volcanoes loomed among the jagged peaks that protruded from the horizon. As the Sun started to set and a pink hue flooded the sky, the dazzling stars started to reveal themselves. I couldn't imagine the beauty I was about to witness.

I was fortunate to visit the Atacama earlier this year and was welcomed with some of the best skies I have ever seen. After three weeks of traversing the Moon-like terrain, I found that the best places for stargazing were in the true heart of the Atacama region.

The Atacama Desert isn't merely great for stargazing, it's renowned as one of the finest places in the world for it. Witnessing some of the darkest skies on Earth from here is a truly unforgettable experience. Several factors combine to make it astronomically ideal: its high altitude, its geographical location and its cold temperatures create the near-perfect conditions for observing the sparkling skies above.

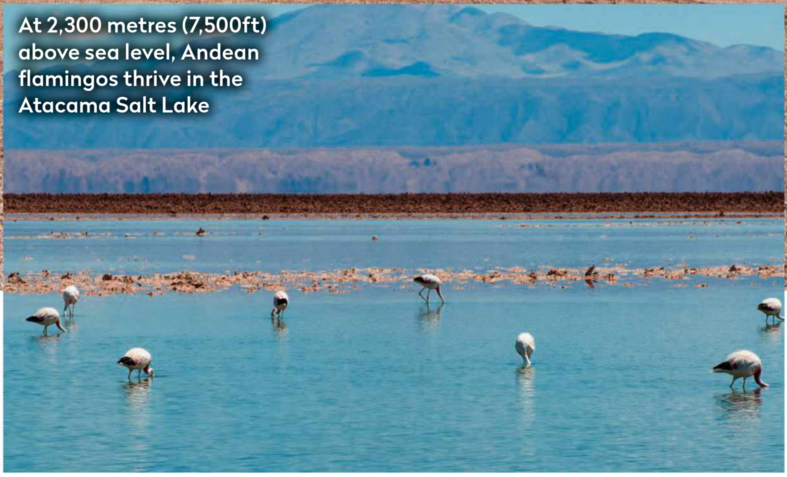
Situated in the Southern Hemisphere in the north of Chile, the Atacama is the driest non-polar desert in the world. It formed between the towering Andes mountain range and the smaller mountains that hug Chile's northern coastline, the Chilean Coastal Range. These coastal peaks block clouds from the Pacific, while the Andes stop moisture from the Amazon basin – together shaping the desert's extreme aridity over time.

With less than 30mm of rain per year, the region has become one of the driest places on Earth. The area's unique ►

MORZINE77, GETTY

LA FRONTERA
OJOS DEL SALADO

From snow-capped volcanoes to shimmering salt flats, the Atacama is a tapestry of contrasts



At 2,300 metres (7,500ft) above sea level, Andean flamingos thrive in the Atacama Salt Lake

▲ Relatives of the llama, vicuna roam the yellow, brush-covered high plains

▶ geography was a surprise to me, as I had never experienced a landscape like it before. I had visited this region before, but I followed the coastal route, visiting the small fishing villages and sampling the day's catch. Inland from the Chilean Coastal Range, the experience is something entirely different.

A landscape full of surprises

The stark contrast between Chile's coast and the high desert is incredible and difficult to imagine until you're there. Salt-crusted flats and golden canyons adorned the roads as we wound through the Mars-like terrain. Following the tourist route known as Ruta del Desierto, we passed a variety of scenes: pink flamingos paddling on the shores of the Salar de Atacama (Atacama Salt Lake), and vicuna (relatives of the llama) springing like deer through the yellow brush that lay like a blanket across the desert floor. The Atacama isn't your typical desert with golden dunes rolling endlessly to the horizon; it presents a diversity of colours, textures, flora and fauna.

Altitude plays a significant role in this dramatic change in scenery, as the Atacama spans from sea level to remarkable heights – making some regions better suited to stargazing than others. Many locations are above 6,000 metres (19,500ft), the highest point being the dormant volcano Ojos del Salado, which reaches an altitude of 6,893 metres (22,615ft). Air is less dense at such altitudes, meaning there is less distortion when looking up at the stars.

However, stargazing in the Atacama isn't without its challenges. The altitude can be dizzying, especially if you head up to high-elevation spots like the Chajnantor plateau, home to the Atacama Large Millimeter/Submillimeter Array (ALMA). Most visitors will stay around 2,400 metres (7,800ft) during their adventures and, to help ease the effects of altitude, only take day trips to surrounding attractions at higher elevations. But it's worth it for the night skies; indeed, even at lower elevations, you'll notice a difference in the clarity of the sky compared to being at sea level.

Although the region is a harsh environment for those who live there, the Atacama's geography and high elevation ensure an exceptionally high chance

> *"The Atacama spans from sea level to remarkable heights… but even at lower elevations, you'll notice the clarity of the sky"*

SERGII BROSHEVAN, ALAMY | PHILIP GAME, ALAMY | INFOCUSPHOTOS.COM, ALAMY | MAP: FRANKRAMSPOTT, GETTY | LUC NOVOVITCH, ALAMY

Ready for an Atacama adventure?

What to consider before a stargazing trip to Earth's darkest skies

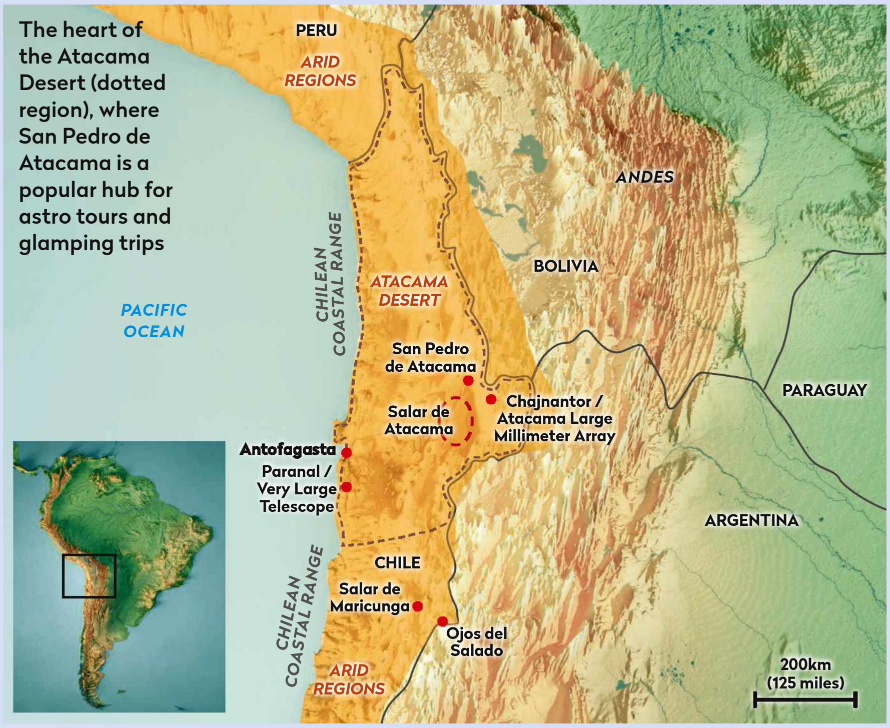
With high temperatures during the day which quickly drop at night, the Atacama region can be challenging to navigate as a first-time visitor. You'll likely start at the town of San Pedro de Atacama, the epicentre for stargazing in the Atacama Desert, and the place from which several tours operate. Many tours take you out of town and some even to the ALMA telescope. Generally, tours operate at night, with guides that bring a selection of telescopes along and point out constellations, planets and more to observe.

It's less common to find overnight tours, but there are several glamping sites that are well located for this. Look for local guides and tour operators based in San Pedro de Atacama.

Warm layers, thermals, plenty of water, a good jacket and suitable footwear are highly recommended. For my trip, I invested in merino base layers, a good down jacket and a windbreaker to cope with the extremes.

The Atacama varies in altitude, but for the best stargazing, you'll likely be above 2,000 metres (6,500ft), so it's a good idea to acclimatise beforehand or consider taking altitude-sickness medication to make your experience more enjoyable.

The summer months, December to March, are peak times for tourists, but as winter approaches, the days get shorter and colder, and the area becomes quieter. A good time to visit is April, the shoulder season – it's free from mass tourism and the colder evenings bring fresh skies.


The heart of the Atacama Desert (dotted region), where San Pedro de Atacama is a popular hub for astro tours and glamping trips

▲ **Pristine skies at Chajnantor plateau let ALMA's dishes tune in to the Universe's faintest signals**

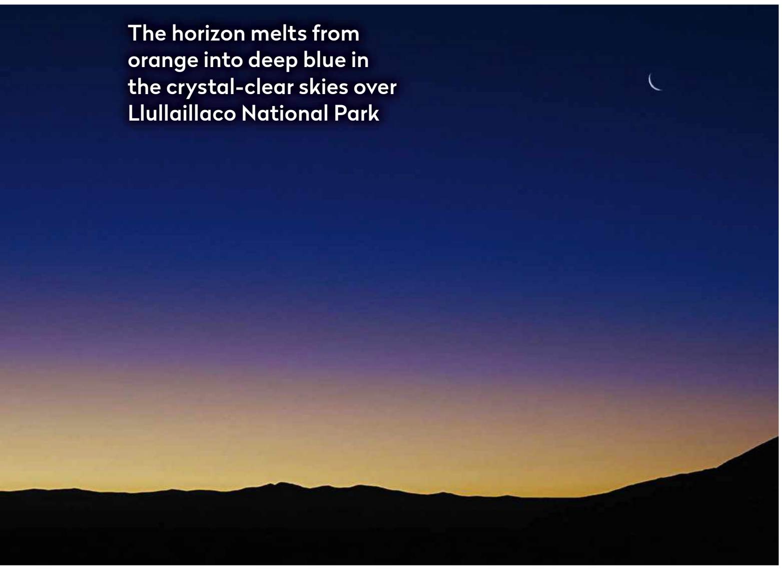
of clear night skies. The absence of moisture means cloud formations are rare. This, combined with its remoteness and near-total lack of light pollution from cities and other urban areas, creates ideal conditions for observing the night sky with the naked eye. The region is considered to have the cleanest skies in the entire Southern Hemisphere, with almost 300 clear nights a year. Altogether, thanks to its unique position between the coastal range and the Andes peaks, the Atacama offers conditions that have drawn astronomers for decades to study our Universe and test equipment destined for space expeditions.

Thanks to its near-perfect night skies, the Atacama is home to several international telescopes and is one of the few locations on Earth to reach the darkest sky reading of 1 on the Bortle scale. The European Organisation for Astronomical Research in the Southern Hemisphere (also known as ESO) has used the Atacama as a base for its Southern Hemisphere telescopes since the 1960s, and continues to invest in new astronomy facilities, such as the Extremely Large Telescope (ELT), due to see first light in 2029.

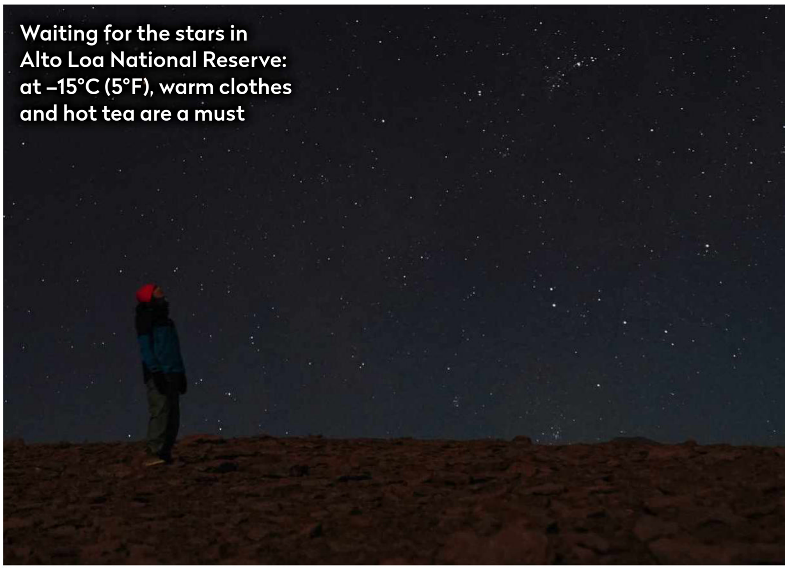
Dark skies, deep science

ESO is comprised of 16 member states and operates several astronomical observatories in Chile's Atacama region; as well as ALMA, there's La Silla, Paranal and Chajnantor. Each site hosts telescopes that observe the night sky across a range of wavelengths. ALMA, for instance, is a network of 66 high-precision, interlinked radio dishes forming an interferometer. It's one of the most sensitive facilities for studying alien worlds forming around distant stars, and – as a key part of the global network that together makes up the Event Horizon Telescope – contributes to the direct imaging of black holes. ▶

Becca's group set up camp on Pajonales' saline plains, just in time to see the Milky Way scroll into view

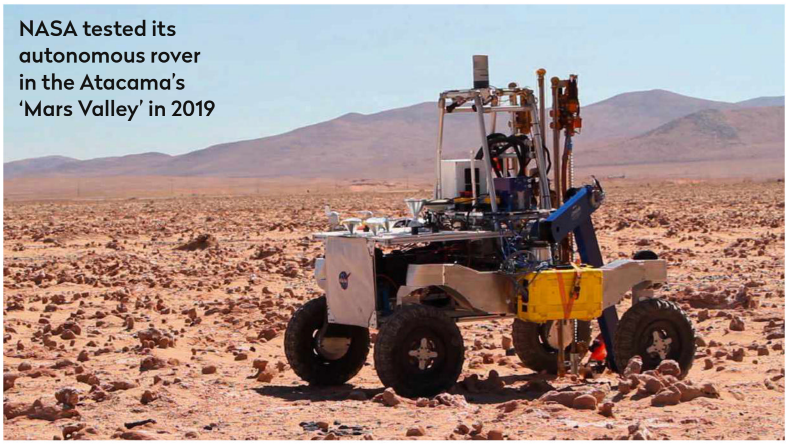


The horizon melts from orange into deep blue in the crystal-clear skies over Llullaillaco National Park



Waiting for the stars in Alto Loa National Reserve: at –15°C (5°F), warm clothes and hot tea are a must

▶ But astronomers don't come here just for the stars. In addition to world-class observatories, the Atacama is home to the 'Valley of the Moon' and 'Mars Valley', areas near San Pedro de Atacama that have been used to test space technology. It felt like I was on another planet as I drove through these regions. I could see the heat creating mirages in front of me as red dust kicked off the ground. Small pockmarks on the surface resembled images I had seen of the Moon, so it was no surprise to learn that this part of the desert had been used by NASA to test rover prototypes such as K-REX2 (shown right).



NASA tested its autonomous rover in the Atacama's 'Mars Valley' in 2019

Simply wondrous

However, you don't need the multi-million-dollar equipment of a space agency to successfully stargaze in the Atacama. In fact, you really don't need much equipment at all to enjoy a night under the stars. From San Pedro de Atacama, you can drive along the Ruta del Desierto and visit many places far from cities and light pollution, offering a truly wild landscape to set up camp. The beauty of the Atacama is that anyone can engage with the night sky: you will see something if you are an amateur looking to learn from a guide, or a hobbyist heading

BECCA MARSH X 3 | NASA, CAMPOALTO, VICTOR ROBLES | ESO, S. GOEBEL | ESO, S. FANDANGO | EYEEM MOBILE GMBH, GETTY

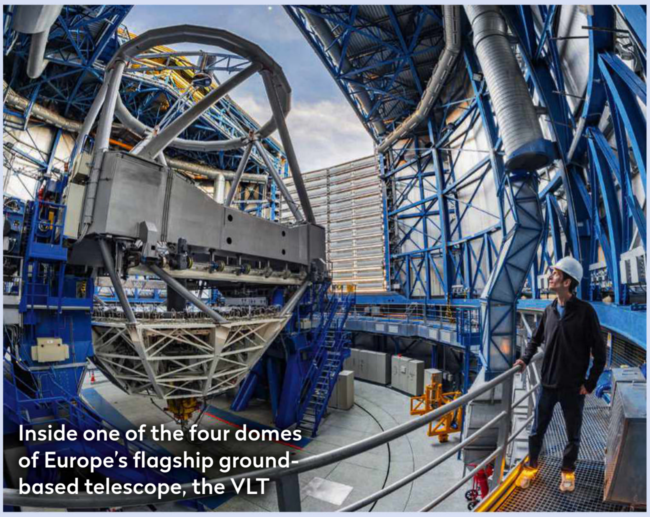
One BIG destination: visiting the VLT

Take a tour of the world-famous Very Large Telescope

The VLT (Very Large Telescope), comprising four 8.2-metre-diameter telescopes constructed in the 1990s, is one of ESO's most famous instruments in the Atacama Desert. Located near the coast, 120km (75 miles) south of the port city of Antofagasta and a four-hour drive from San Pedro de Atacama, it's among the world's most advanced visible-light observatories.

Visiting the VLT is free, with tours kicking off with a brief overview of the Paranal site. From the base of the telescopes, you're introduced to the area and can admire views of the Andes to the east before entering one of the domes. The tour concludes with a quick stop at the astronomers' residence, made famous as a location in the James Bond film *Quantum of Solace*.

Tours last between two and three hours. It's worth noting that public visits are only available on weekends and during the day, as astronomers use the telescopes at night. There are two daily time slots for visits, and bookings for the Paranal Observatory can be made via the ESO website at www.eso.org/public/about-eso/visitors/paranal.



Inside one of the four domes of Europe's flagship ground-based telescope, the VLT

Home away from home for VLT astronomers, the residencia that featured in *Quantum of Solace*

▶ You don't need fancy equipment – just wrap up warm and get ready for the Atacama to reveal our Universe

Accredited travel writer **Becca Marsh** explores the natural world and culture, with a passion for overland adventures and sharing her experiences

out into the wilderness with a stargazing app and a pair of binoculars. All you need is patience, a keen eye and some warm layers!

One of my favourite wild camp spots for stargazing was Salar de Maricunga, just off Chile's Route 31. The altitude is higher here, just below 4,000 metres (13,000ft) and, in April, extremely cold – so it pays to be prepared.

On my visit, the Sun set around 7pm, so I sat down in my dusty camping chair and waited for the show to begin. As a keen photographer, I had my camera, tripod and a simple pair of binoculars, and I was set. I sat around the camp with my fellow camp-mates, and we passed the binoculars around, pointing out constellations we recognised.

A cold shiver came over me as I set up my camera, ready to capture the clear night sky. I looked up and was overwhelmed by the colours; hues of purple and blue danced in front of me. It was as if a light switch had been turned on.

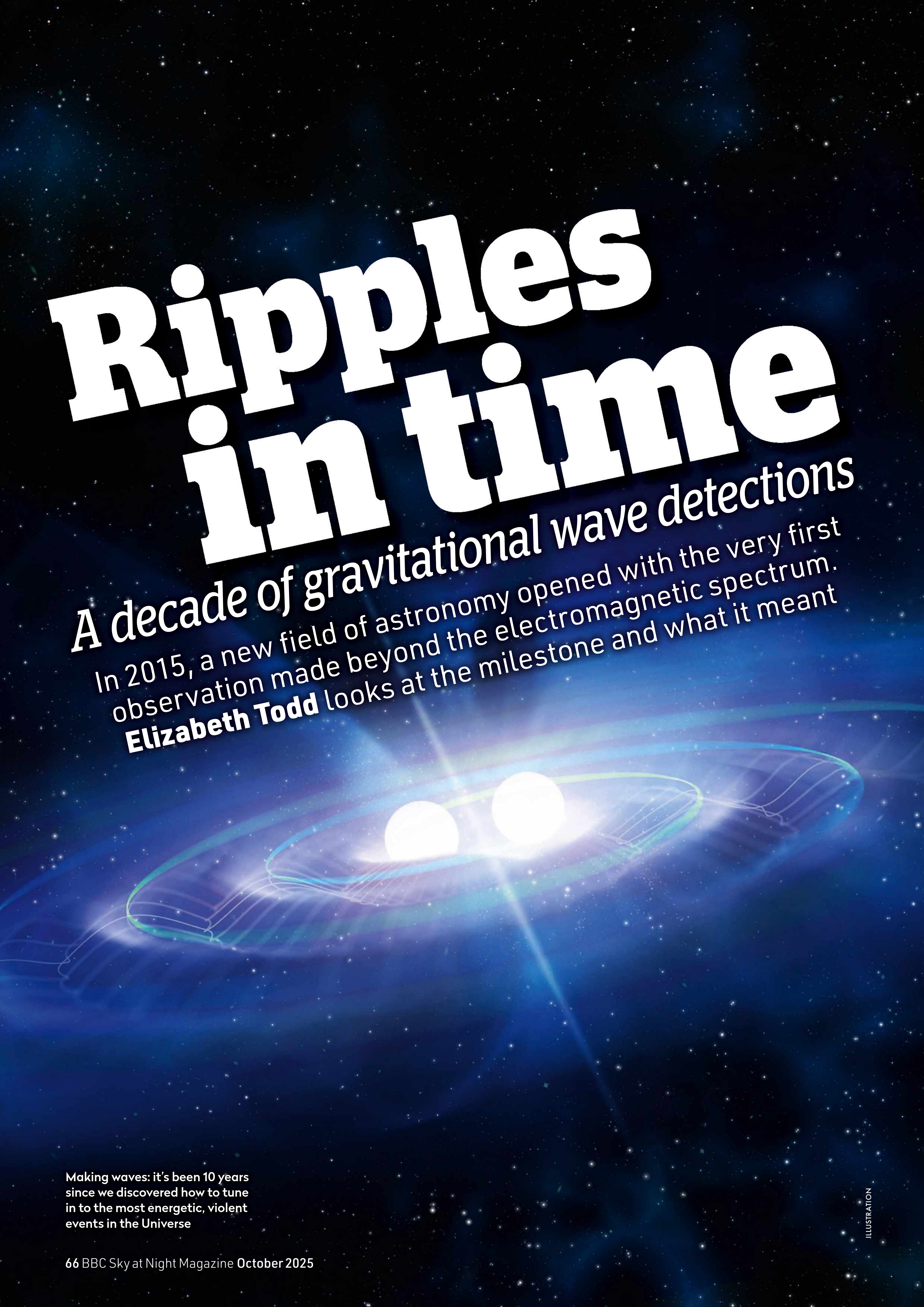
The sky deepened from sunset to a bold dark blue, and stars began to appear. Then the Milky Way revealed itself, stretching from one horizon to the other like a pathway that was paved with starlight. I've seen it before, but only very faintly – never like this. Every thread of cosmic dust, every star cluster, was visible, glowing in high definition.

I was so mesmerised, I had forgotten about the cold, and before I knew it, I couldn't feel my toes. But it was 100 per cent worth it – a small price to pay for such a reward. It still amazes me how this place came to be, and that by chance natural geography has created one of the most perfect locations on Earth for exploring the cosmos.

Ripples in time

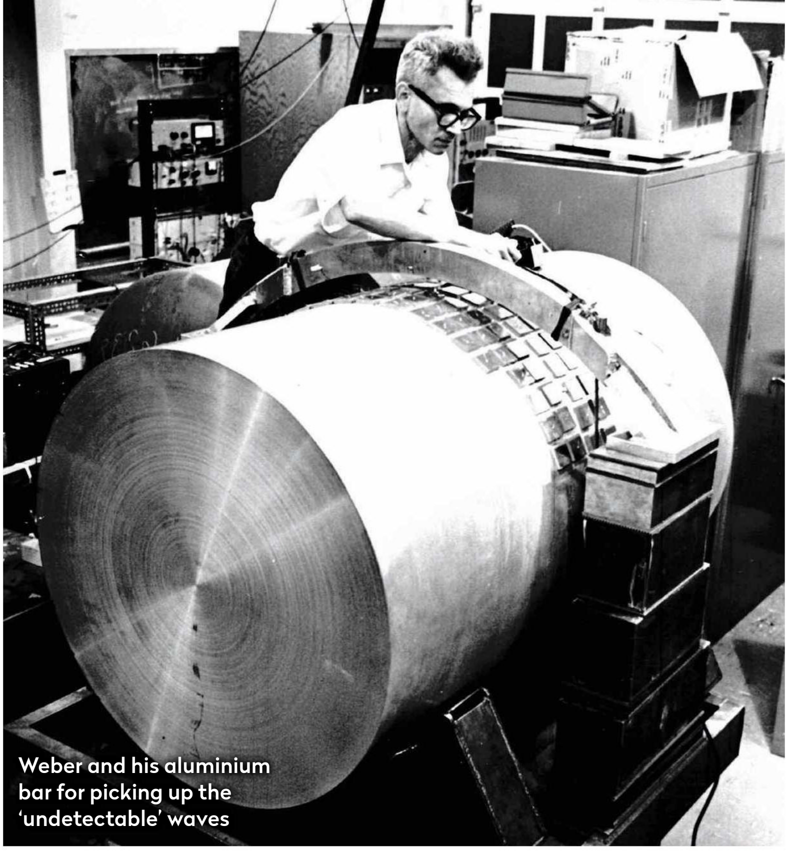
A decade of gravitational wave detections

In 2015, a new field of astronomy opened with the very first observation made beyond the electromagnetic spectrum. **Elizabeth Todd** looks at the milestone and what it meant



Making waves: it's been 10 years since we discovered how to tune in to the most energetic, violent events in the Universe

ILLUSTRATION



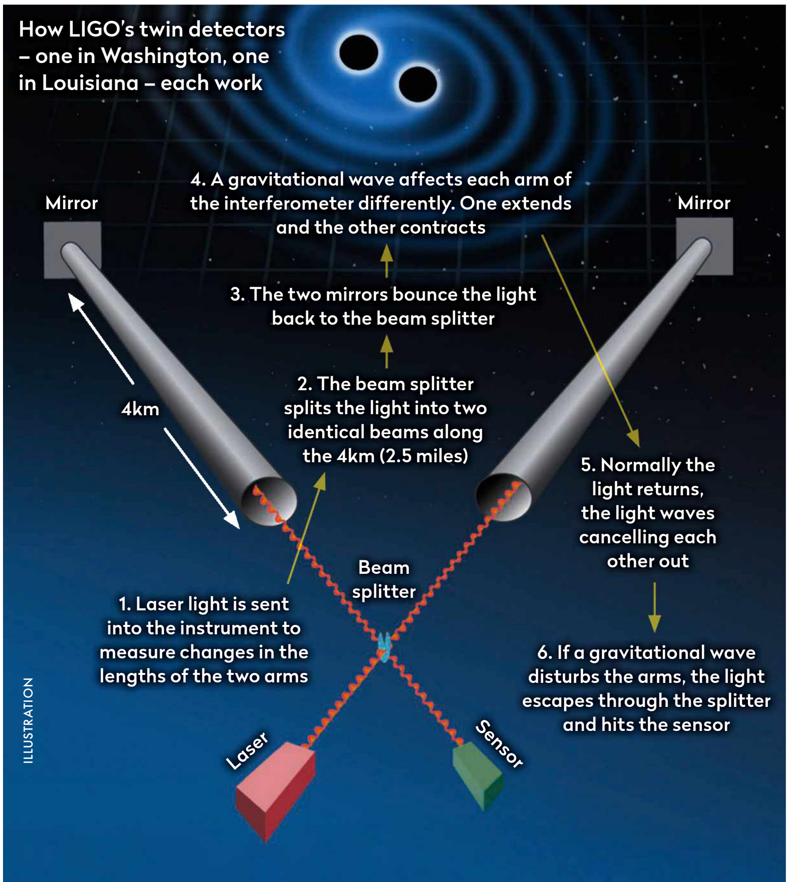
Weber and his aluminium bar for picking up the 'undetectable' waves

Ten years ago, on 14 September 2015, a new window on the Universe was opened, giving us a novel way of studying exotic, high-energy objects such as black holes and neutron stars: the first direct detection of a gravitational wave was made by LIGO (the Laser Interferometer Gravitational-Wave Observatory). Now that a decade has passed, let's take a look at some of the events leading up to the groundbreaking detection of these ripples in spacetime and the exciting discoveries made since.

But where did the idea of looking for gravitational waves come from? Einstein himself suggested it, but he thought we would never detect them. This was taken as a challenge by many scientists, who set out to detect these 'undetectable' waves. In the 1960s, Joseph Weber began building resonant bar detectors, aluminium cylinders that would vibrate if a gravitational wave was to pass through. While the detectors were not shown to make detections, Weber's legacy lives on. Following his lead, having detectors at geographically separate locations helps to determine whether a signal is from a gravitational wave or a more local source such as an earthquake.

The first indirect evidence of the existence of gravitational waves was published by physicist Russell Hulse and astrophysicist Joseph Taylor Jr, who discovered the first binary pulsar system PSR B1913+16 in 1974. They knew, from Einstein's theory, that if the system was emitting gravitational waves, it would be losing energy and the stars would spiral into each other, their orbital period decreasing as the distance between them shrank. Now, with 50 years of data, the measurements agree with Einstein's predictions to within 1 per cent.

Elizabeth Todd is an MSc student at Cardiff University and about to begin a PhD in gravitational waves at the University of Glasgow



How LIGO's twin detectors – one in Washington, one in Louisiana – each work

Mirror
Mirror
4km
1. Laser light is sent into the instrument to measure changes in the lengths of the two arms
2. The beam splitter splits the light into two identical beams along the 4km (2.5 miles)
3. The two mirrors bounce the light back to the beam splitter
4. A gravitational wave affects each arm of the interferometer differently. One extends and the other contracts
5. Normally the light returns, the light waves cancelling each other out
6. If a gravitational wave disturbs the arms, the light escapes through the splitter and hits the sensor
Beam splitter
Laser
Sensor

ILLUSTRATION

Perfecting the science

By the 1970s, the race to directly detect gravitational waves had begun. Research groups from all over the world began building the first prototype gravitational wave detectors, moving away from Weber's resonant bars and towards laser interferometers. These devices exploit the fact that the speed of light is always constant, another tenet of Einstein's theories. They work like this: the interferometer splits a laser beam in two, sending each half down perpendicular arms with mirrors at their ends reflecting the beams back to meet each other. Depending on the relative distances travelled, the beams can constructively interfere (add together) or destructively interfere (cancel out). Gravitational waves stretch spacetime in one direction and squeeze it in the perpendicular direction, so a passing wave changes the interferometer's arm lengths by tiny amounts, altering the interference and providing a direct way to measure gravitational waves.

After several decades of technology demonstrations, including the British–German GEO 600 detector, the first interferometer gravitational wave detectors to be built were the twin LIGO detectors in the US states of Louisiana and Washington. The hunt for gravitational waves had begun. With arms 4km (2.5 miles) long, these were later joined by the Virgo detector sited near Pisa, Italy. The first 'science runs' of this Initial LIGO setup paired with Virgo were completed between 2002 and 2010, and while they demonstrated that the detectors worked, they were not expected to make any detections. The detectors were then upgraded ▶

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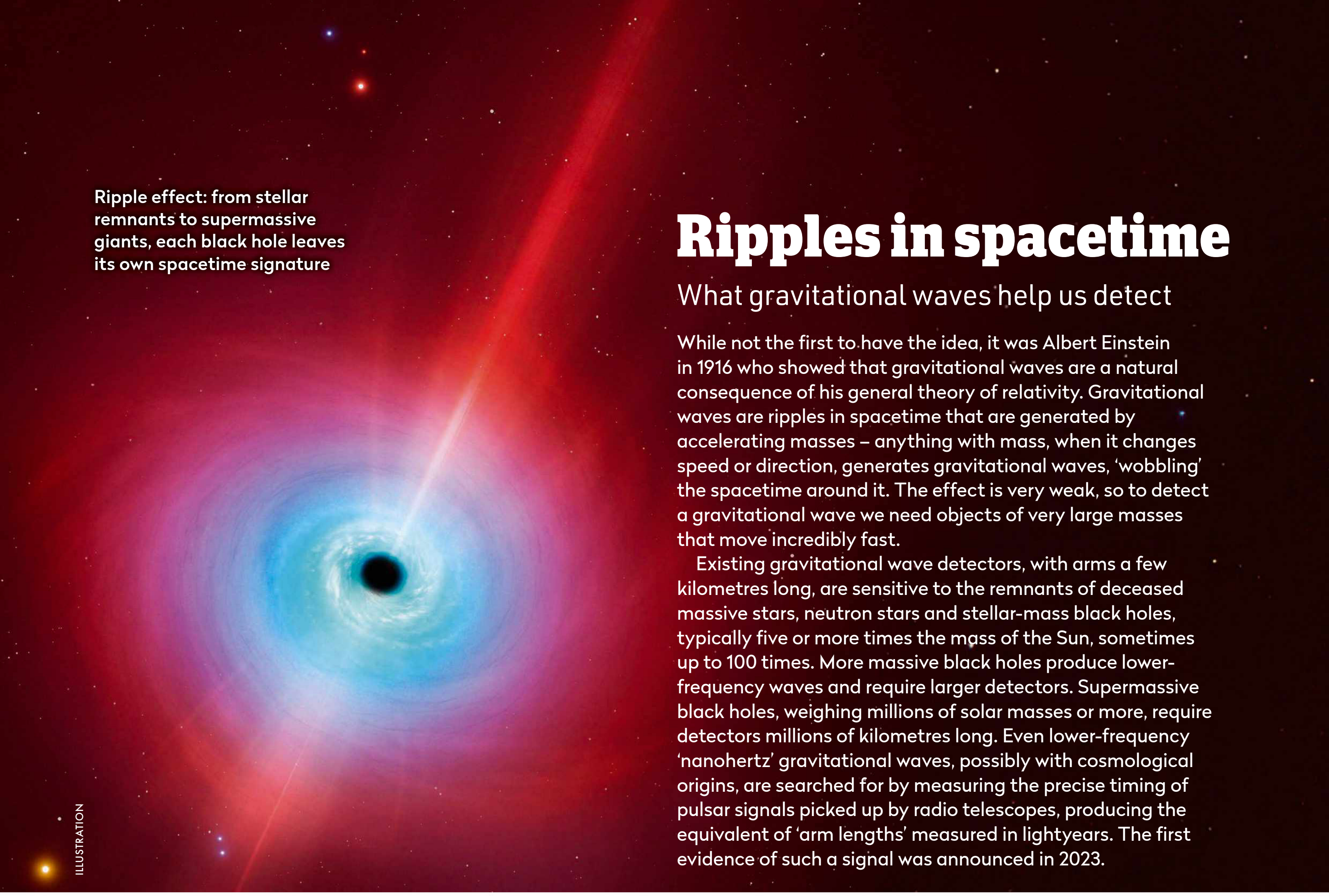

Ripple effect: from stellar remnants to supermassive giants, each black hole leaves its own spacetime signature

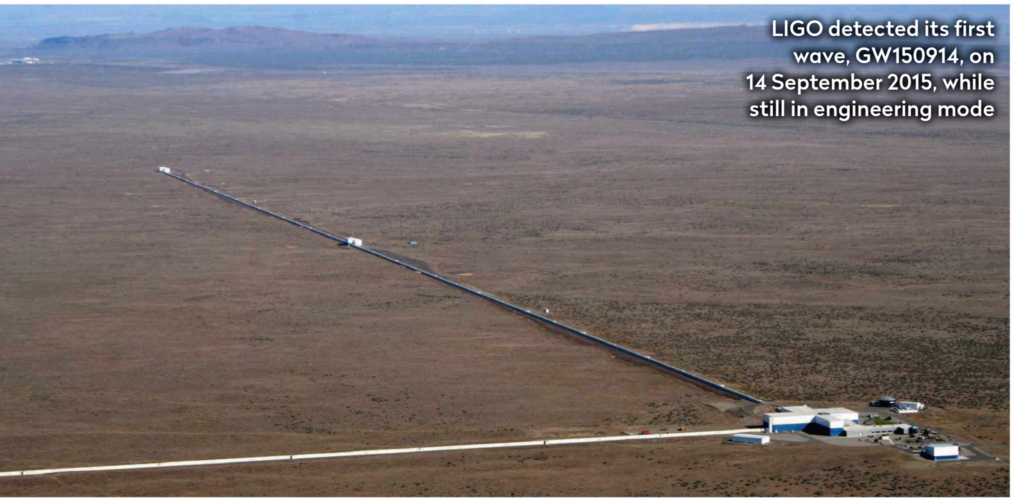
ILLUSTRATION

Ripples in spacetime

What gravitational waves help us detect

While not the first to have the idea, it was Albert Einstein in 1916 who showed that gravitational waves are a natural consequence of his general theory of relativity. Gravitational waves are ripples in spacetime that are generated by accelerating masses – anything with mass, when it changes speed or direction, generates gravitational waves, 'wobbling' the spacetime around it. The effect is very weak, so to detect a gravitational wave we need objects of very large masses that move incredibly fast.

Existing gravitational wave detectors, with arms a few kilometres long, are sensitive to the remnants of deceased massive stars, neutron stars and stellar-mass black holes, typically five or more times the mass of the Sun, sometimes up to 100 times. More massive black holes produce lower-frequency waves and require larger detectors. Supermassive black holes, weighing millions of solar masses or more, require detectors millions of kilometres long. Even lower-frequency 'nanohertz' gravitational waves, possibly with cosmological origins, are searched for by measuring the precise timing of pulsar signals picked up by radio telescopes, producing the equivalent of 'arm lengths' measured in lightyears. The first evidence of such a signal was announced in 2023.


LIGO detected its first wave, GW150914, on 14 September 2015, while still in engineering mode

▶ to the level expected to pick up gravitational waves from astrophysical sources, and the first observing run of the Advanced LIGO setup (aLIGO), called O1, began in September 2015.

And so it was that on 14 September 2015, almost 100 years after Einstein predicted their existence, gravitational waves were first detected directly. That first detection, dubbed GW150914 (gravitational waves are named after their detection date, in US format: 2015-09-14), was created by two black holes 1.4 billion lightyears away, each around 30 times more massive than the Sun, and each formed by the deaths of even more massive stars. LIGO was able to detect ~200 milliseconds of gravitational wave data as the black holes spiralled together before merging.

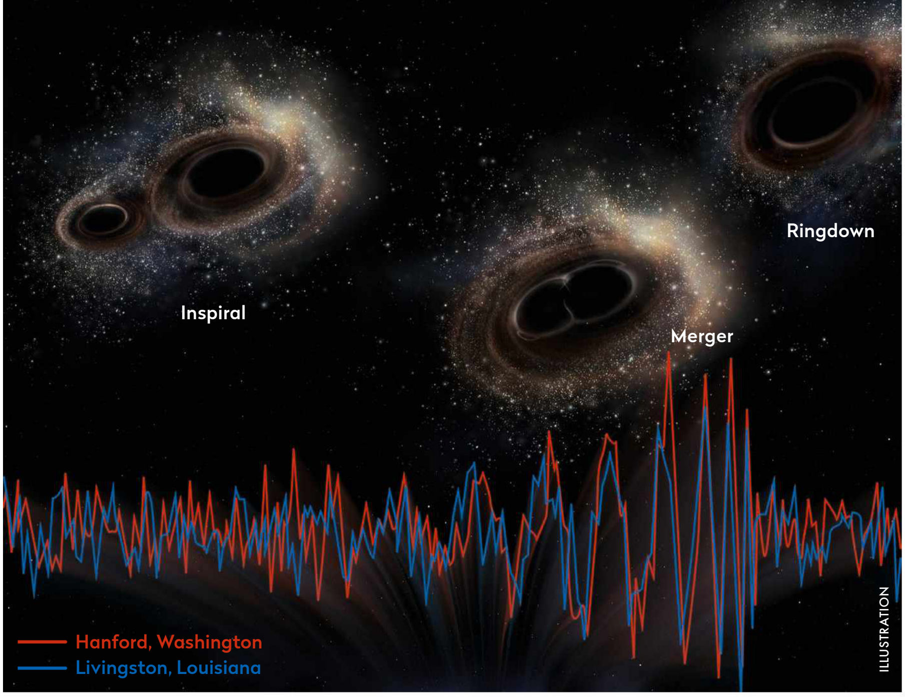
Triumph in test mode

No one expected to see a detection so soon, and there was an element of luck involved; O1 hadn't officially begun, and the detectors were formally still in testing mode. Worries that the detection was the result of a hack or a preparatory test signal spread, but were quickly allayed. Two more detections followed before O1 ended in January 2016 and the LIGO–Virgo Collaboration published its discoveries in February 2016. Accolades followed, and three key LIGO figures, Barry Barish, Kip Thorne and Rainer Weiss, won the 2017 Nobel Prize in physics.

In November 2016, the observing began again with O2, this time with increased sensitivity thanks to Advanced Virgo coming online in August 2017. Out of the eight new events, the most notable occurred on 17 August 2017, GW170817.

In a joint detection between LIGO, Virgo and over 70 telescopes covering gamma ray, radio, X-ray and optical light, a flash of electromagnetic waves originating in the galaxy NGC 4993 was seen to coincide with a gravitational wave signal. This was the first multi-messenger detection, using both gravitational and electromagnetic waves to find the source, a binary neutron star merger – more than four decades after Hulse and Taylor had discovered the first binary pulsar. The merger formed a kilonova, an object less bright than a supernova, but with an afterglow that was still visible for over a year after the first detection. Using data collected from both gravitational and light waves, these multi-messenger events usher in the prospect of understanding the nature of neutron stars and making an independent measurement of the Universe's expansion.

Gravitational wave detectors are highly sensitive instruments and so are



▲ The 0.2-second signal for GW150914 matched the inward spiral, merger and ringdown (final period of settling) of a pair of black holes, each around 30 times the mass of the Sun

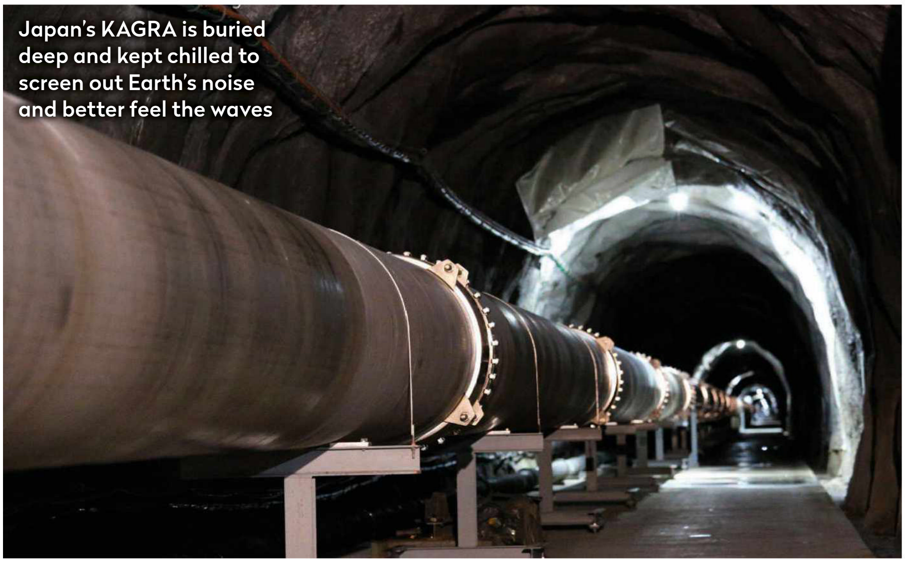
susceptible to many non-astrophysical sources, like seismic noise and human activity (trucks, trains, or even electronics). To combat this, scientists in Japan built a gravitational wave detector 200 metres underground, in the Kamioka mine. This detector, called KAGRA, uses cryogenic technology to cool its mirrors to reduce thermal effects, another prominent noise source, and started observing for the last two months of the third observing run, O3, in February 2020.

A single gravitational wave detector alone can't pinpoint a merger's location; two produce a ring or arc of possible locations in the sky. Adding more detectors to the search narrows down the directions a wave could have originated from, in a similar way to using triangulation when navigating.

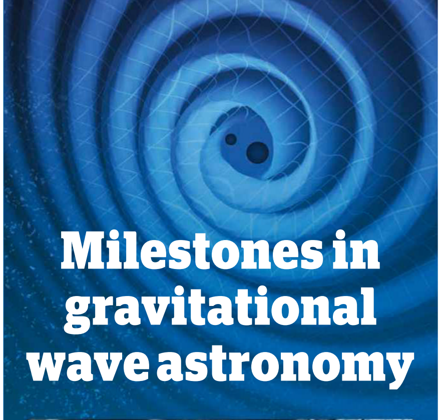
Before the O3 observing run, the detectors' sensitivity was significantly upgraded, so that the maximum detection range of binary black holes was nearly doubled. Such an increase in detection range meant the detectors were sensitive to over five times the volume of space, bringing the total detections to almost 100.

Filling the mass gap

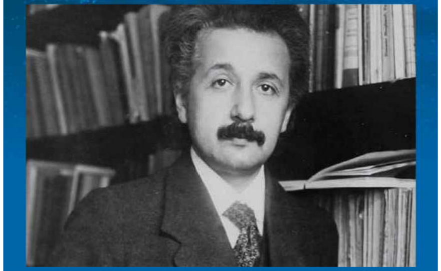
The source objects have a wide range of masses, but observations show a gap between the most massive known neutron star, at around 2.5 solar masses, and the least massive black hole, at around five solar masses. One of O3's more intriguing events, 2019's GW190814, originated from the merger of a black hole 23 times the mass of the Sun with a much smaller object just 2.6 times the mass of the Sun. Whether that lower-mass object was the lightest known black hole or the heaviest neutron star is unknown, but either way, LIGO and Virgo had detected something sitting in the mass gap for the first time, challenging explanations of this system's formation. ▶



Japan's KAGRA is buried deep and kept chilled to screen out Earth's noise and better feel the waves



Milestones in gravitational wave astronomy



May 1916: Albert Einstein predicts gravitational waves

September 1974: Hulse and Taylor's binary pulsar discovery using the Arecibo radio telescope

ILLUSTRATION

March 1990: first European Pulsar Timing Array observations

1994: construction of LIGO begins

August 2002: Initial LIGO begins science observations

September 2015: LIGO detects GW150914 from a black hole merger

August 2017: Advanced Virgo starts observing

August 2017: GW170817 detected, produced by a neutron star merger; multi-messenger astronomy begins

April 2020: KAGRA starts observing

ILLUSTRATION

April 2023: LIGO-India construction is approved

June 2023: first evidence from pulsar timing arrays announced

March 2025: O4 observing run surpasses 200 detections

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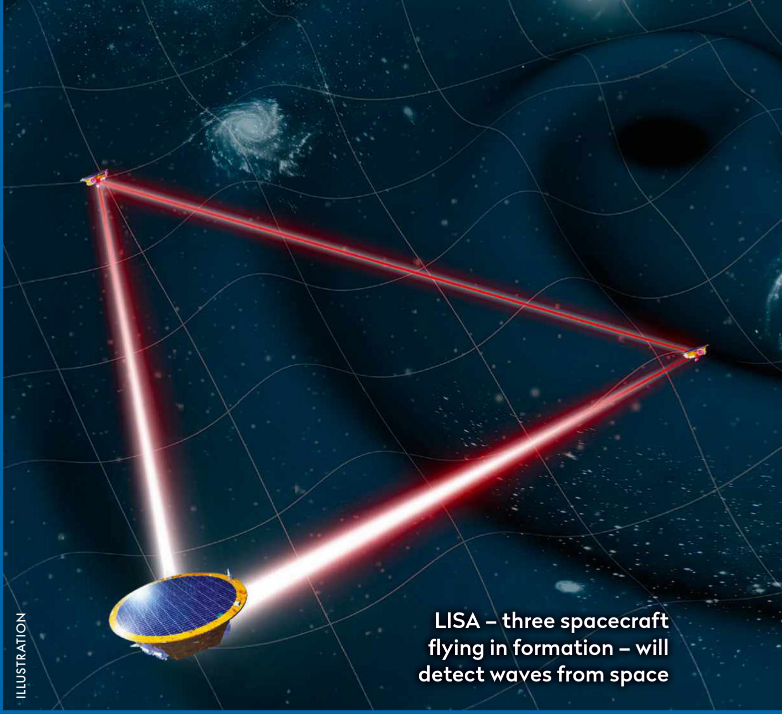
Future detectors

What's on the horizon for gravitational wave science in its second decade?

Following post-O4 upgrades, observing run O5 is planned for 2028–31, after which even more significant upgrades will be made. At the start of the next decade, the plan is for a fifth detector, LIGO-India, to join the search for gravitational waves. Plans are also proposed to construct two brand-new detectors in the US and Europe: Cosmic Explorer, with arms 10 times longer than LIGO's, and the Einstein Telescope, with 10km (6.2-mile) arms built underground and cooled cryogenically. These aim to detect virtually all mergers of stellar-mass black holes in the observable Universe.

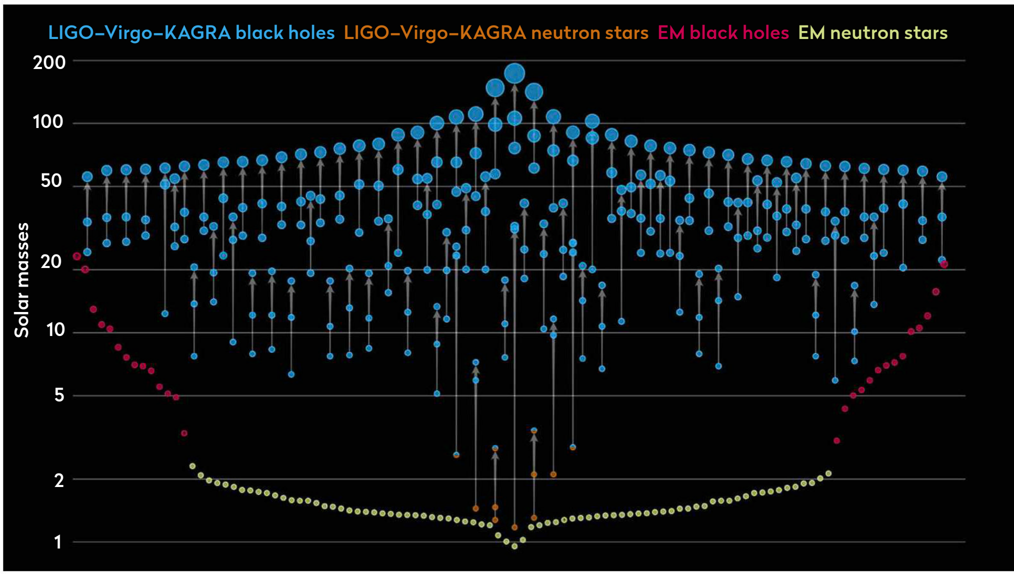
The 2030s will also see the launch of the first space-based gravitational wave observatory. The Laser Interferometer Space Antenna (LISA) is led by ESA in collaboration with NASA and an international consortium, and comprises three spacecraft millions of kilometres apart. LISA will search for the mergers of supermassive black holes in the hearts of distant galaxies, and much lower-mass white dwarf binaries within our own Milky Way. LISA has already had a technology demonstration mission, LISA Pathfinder, heralded as one of ESA's most successful test missions ever.

Meanwhile, researchers are using data from the LIGO–Virgo–KAGRA collaboration to push Einstein's theories to the limit and even hunt the signature of some models of dark matter.



LISA – three spacecraft flying in formation – will detect waves from space

▶ Today we are coming towards the end of the fourth observing run, O4. In the break between O3 and O4, upgrades were again added to the LIGO detectors, so that it is now known as A+ LIGO. The upgrades reduced thermal and quantum noise (the latter by exploiting the quantum nature of light) and further increased the detection range.



▲ **Gravitational waves detected, in ascending order of mass and coloured according to the source object/event that created them (arrows show the minimum and maximum mass of the source object), plus those discovered via electromagnetic telescopes**

Where next?

To date, over 200 gravitational wave events have been detected during O4 alone, including the heaviest merger ever detected by LIGO, GW231123. Intriguingly, it's possible that the two black holes that caused this event, 137 and 103 times the mass of the Sun, were the result of a previous generation of mergers. Many more exciting events are expected to be detected before O4 ends in November 2025, with the final stages coinciding with the first observations of the Vera C Rubin Observatory in Chile. This will test collaborative efforts to make more multi-messenger detections of binary neutron star mergers.

While gravitational wave data provides us with a lot of information about the nature of black holes and neutron stars, including how they form, it can also be very useful in other areas of fundamental physics, such as testing Einstein's theory of gravity and the search for dark matter.

While the detectors were built to identify gravitational waves from colliding black holes and neutron stars, astronomers at Cardiff University have used data from the LIGO detectors to look for something else: dark matter particles. For their analysis, this team used software made for the music industry to analyse the data amazingly fast, producing results in real time. No evidence for dark matter has been found yet, but the search continues.

Using gravitational wave data, we have been able to set upper mass limits on the theorised gravity particle, the graviton, test the validity of current black hole models, and see how well general relativity can describe extreme situations. So far, the results appear to confirm general relativity. However, this isn't to say Einstein's theory is the last theory of gravity we will ever need, and the search continues for a theory of quantum gravity. But that is what's most exciting about physics: one day we will find something even Einstein can't explain, and it will be up to a new generation of scientists to find the solution.

ESA | LIGO, VIRGO, KAGRA, AARON GELLER, NORTHWESTERN

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Edinburgh
Saturday, October 4th, 2025

Join us in Scotland for a day of comet and meteor related astronomy in the centre of Edinburgh.

Our speakers include Nick James, Dr. John Mason, Jonathan Shanklin, Martin Mobberley, Denis Buczynski, Alex Pratt, Bill Ward, Douglas Heggie, Dr. Erica Bufanda and Dr. Jamie Robinson.

This meeting has been arranged in conjunction with the Astronomical Society of Edinburgh and it is open to members and non-members. For full details and a link to the booking form just visit the website.

britastro.org/event/comet-and-meteor-section-meeting

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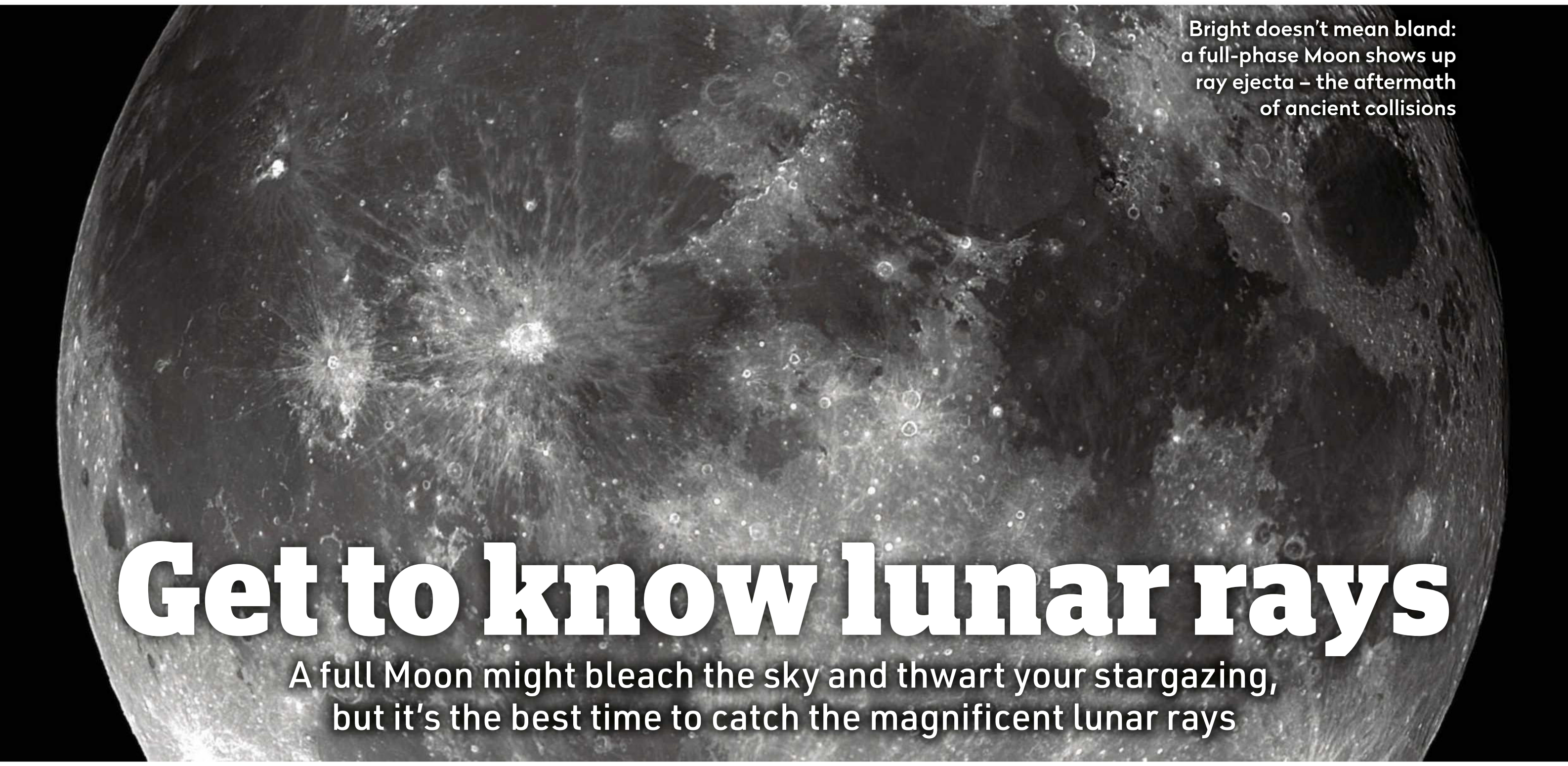
EXPLAINER



Bright doesn't mean bland: a full-phase Moon shows up ray ejecta – the aftermath of ancient collisions

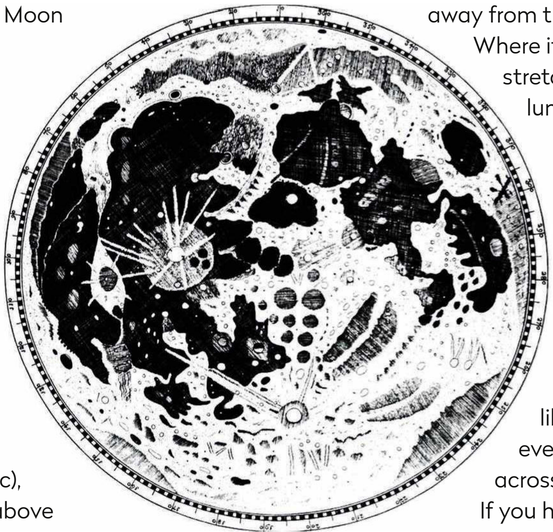
Get to know lunar rays

A full Moon might bleach the sky and thwart your stargazing, but it's the best time to catch the magnificent lunar rays

The worst time to look at the Moon is when it's full, right? Not necessarily. It's true that at full Moon, sunlight hits the surface head-on, flattening the appearance of its rugged landscape of deep craters, towering mountains and meandering valleys, showing only a flat, grey-and-white disc. But this direct lighting reveals something else: lunar rays – bright lanes of shattered rock and fine dust that fan out from impact craters.

While these are hard to see when the Sun is low in the lunar sky (when we see the Moon as a crescent or a gibbous disc), when the Sun's light strikes them from above during full Moon they shine. And with 2025's first supermoon coming on 7 October, there's never been a better time to see them.

Imagine you're standing on the Moon, 100 million years ago, watching a huge asteroid fall from the sky. As it hits, it blasts a crater – maybe 85km (53 miles) wide and 5km (3 miles) deep – out of the surface. It also sprays vast amounts of pulverised rock and dust away from the impact site, which arcs overhead. Where it settles, it leaves long rays of debris stretching back to the crater. That's how lunar rays were formed.



▲ Johannes Hevelius in 1647 was the first to draw maps showing lunar ray systems

Spotting Moon scars

Lunar rays were observed and recorded long before the first grainy photos of the Moon. In 1647, Polish astronomer Johannes Hevelius drew a map of the Moon as it appeared through his telescope. It clearly shows the rays heading away from craters like Tycho, Copernicus and Kepler, and even one of Tycho's longest rays cutting across Mare Serenitatis.

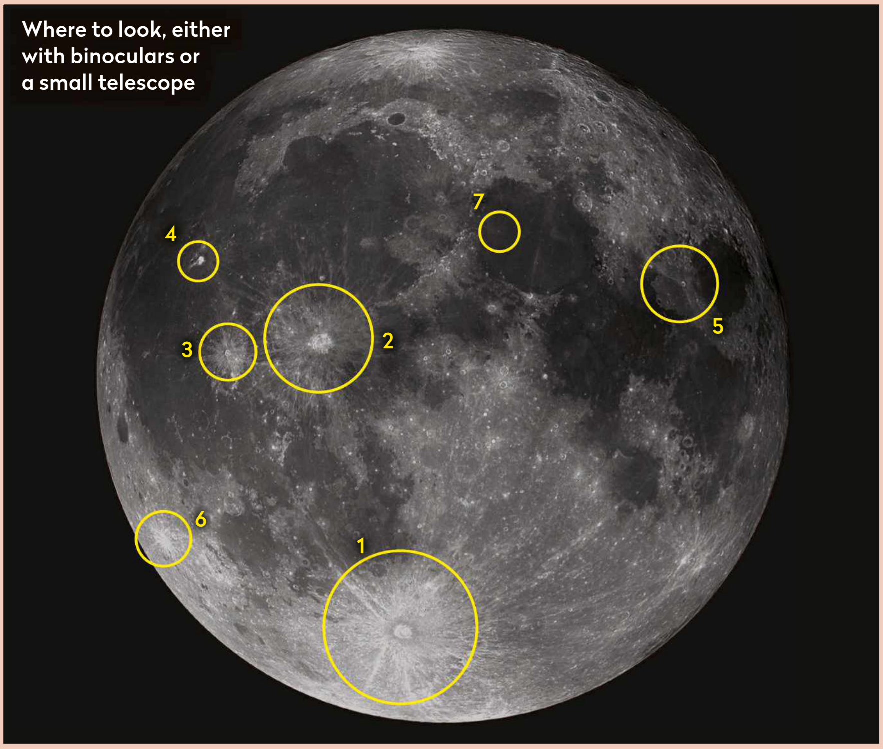
If you have good eyesight, you might glimpse some rays with your naked eye at full Moon, especially when it's just rising or setting, when its glare is dimmed by Earth's atmosphere. Most people, though, will need help from binoculars or a telescope.

Through binoculars, the brightest, longest rays – from Tycho – stand out extremely clearly. When the Moon is low in the sky, you'll be able to trace the rays stretching away from Tycho almost all the way

PETE LAWRENCE X 2 | UNIVERSAL HISTORY ARCHIVE, GETTY | MICHAEL KARRER, CCDGUIDE.COM X 2

Catch some rays! Seven to spot

Find these craters for some lunar-ray-gazing fun during October's supermoon


Where to look, either with binoculars or a small telescope

1. Southern highlands crater **Tycho** is 85km (53 miles) wide and 5km (3 miles) deep, and has the longest rays of any lunar crater – up to 1,500km (930 miles)!

2. Copernicus, lying near the centre of Oceanus Procellarum, is 93km (57 miles) wide and sits at the centre of an elaborate, almost cobweb-like splash of rays.

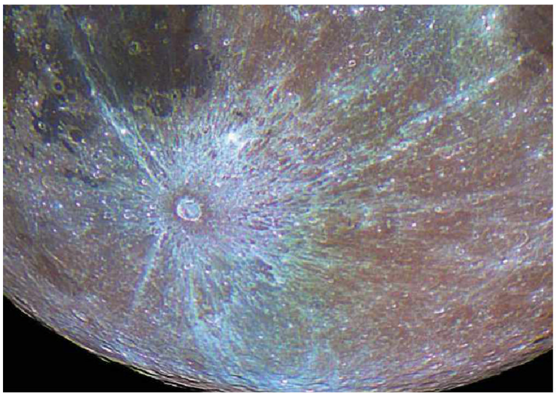
3. Kepler, to the west of Copernicus, is a small, young crater surrounded by a roughly circular spray of bright rays.

4. Small **Aristarchus**, forming a neat triangle with Kepler and Copernicus, has a striking splash of bright impact debris on one side that looks stunning under higher magnifications.

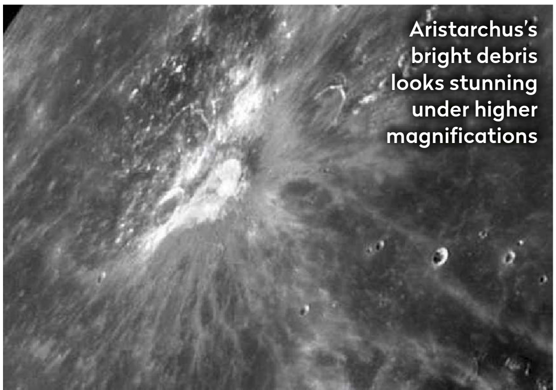
5. Proclus was blasted out of the shore of Mare Tranquillitatis by a shuddering asteroid impact millions of years ago. This bright crater has a broad fan of bright rays spraying away from it that reach into neighbouring Mare Crisium.

6. Located near the Moon's western limb, the ancient crater Byrgius is fairly unremarkable in itself, but when a more recent – in geological terms – impact blasted a smaller crater, **Byrgius A**, out of its rim, bright material sprayed away from it for hundreds of kilometres.

7. The narrow, bright rays seen shooting away from **Messier A** have been compared to a beam shining from a torch. To track it down, look at the eastern shore of Mare Fecunditatis and you'll see what looks like a grey-white comet tail on the dark lava field, stretching away from a pair of small craters: Messier and Messier A. This duo were formed by the impact of an asteroid that most likely came in at a shallow angle and bounced.



◀ **With binoculars you'll be able to trace Tycho's extraordinary rays for hundreds of kilometres**


Aristarchus's bright debris looks stunning under higher magnifications

Stuart Atkinson is a lifelong amateur astronomer and author of 17 books on astronomy and spaceflight

up to the top of the disc, while Copernicus's rays can be followed into the southern part of Mare Imbrium, beside the jagged spine of the Apennine Mountains.

But if you have a telescope, even a small one, your view of the rays will be spectacular. Don't be tempted to crank up the power though; low magnification is best, so you can see the whole Moon and watch the rays crossing its features. Seen through a telescope, the full Moon can be so eye-wateringly bright that you might want to stop down your scope a little by covering half the front of its tube, which will give you a much clearer, kinder view.

Tycho's longest rays can be traced for hundreds of kilometres, stretching from the crater itself up to and across Mare Serenitatis and on into Mare Frigoris. Copernicus's network of rays is so bright and extensive that it looks like white paint that has sploshed out of a dropped tin.

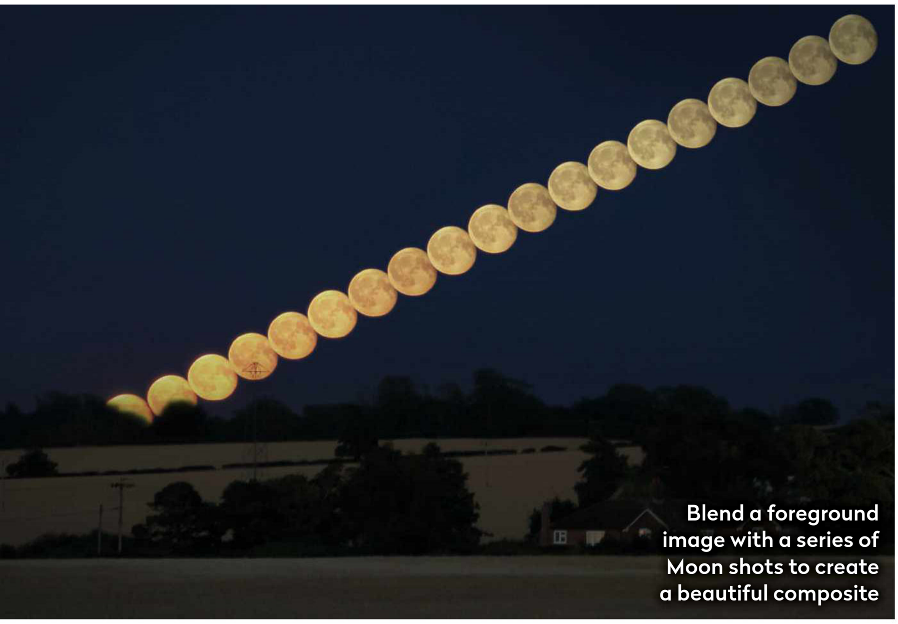
So, don't curse the full Moon – look closer. As it sheds its shadows, it shows its scars. With most other features washed out, it's your best chance to trace the Moon's geology from your own back garden.

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

Create a striking moonrise composite

Here's how to showcase the Moon's graceful ascent from the horizon



Blend a foreground image with a series of Moon shots to create a beautiful composite

One of the greatest draws of astrophotography is how it blends science and creativity. Once you get to know your camera's settings, you'll unlock a plethora of ways to image the night sky. Even a humble DSLR offers plenty of target choices, from complex deep-sky objects like galaxies and nebulae to beautiful landscapes that celebrate our Milky Way.

While DSLRs aren't typically ideal for lunar or planetary photography due to their low frame rates, they're perfect for letting your creativity flow. A great example is capturing the Moon's ascent from the horizon. This involves shooting your foreground and Moon frames separately, then combining them in post-processing. As you can see from our image, not only can you capture lovely lunar surface details with a humble kit lens, you can also record the Moon's apparent colour change, from pinkish-orange to brilliant white, as the light it reflects near the horizon is scattered through our atmosphere.

To shoot a moonrise sequence, start by checking the next full Moon date and the moonrise and set times for your location (try www.timeanddate.com). The best time is during the waxing phase, just before the Moon is full. That's because it rises just after sunset, which also reduces interference from any background stars – helpful when it comes to blending your foreground and Moon frames.

With no stars or Moon visible when you arrive at your location, use a distant landmark to focus. A planning app is an essential tool for choosing a good location. Though they often cost a small fee (PhotoPills, for example, costs £10.99), they're invaluable for landscape imagers. These apps show the Moon's angle of ascent, helping you align your location with its path.

Dial in your settings

Before shooting, set your camera to raw format. For your foreground, manually adjust your settings to achieve depth of field (which requires a mid to high f/ ratio), and balance your ISO and exposure to capture details with minimal blur. Our foreground was captured at f/6, ISO 640, with a 30-second exposure using a Canon 7D DSLR.

As the Moon starts to appear, you'll need to quickly switch and adapt your settings. Depending on your focal length, you may want to narrow your aperture to avoid over-exposing the surface. Perhaps start with f/8 and increase as the Moon fully emerges.

If you want a more detailed lunar surface, use a long-focal-length lens (200mm–300mm); for wider landscape views, a wider lens (75mm–150mm) works well, although the Moon will be less defined.

Finally, setting your intervalometer doesn't need to be an exact science. It's more about consistency: shooting at regular intervals, rather than calculating the perfect gap between frames. That said, it's better to go for short intervals. We shot our Moon frames at 30-second intervals and ended up discarding every other frame to create the effect shown, where each Moon closely touches the next.

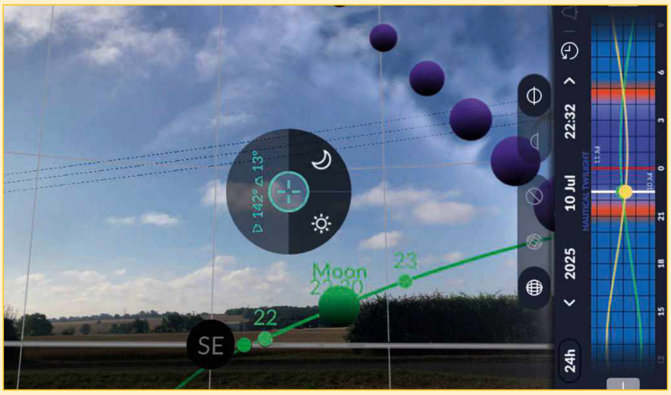
Charlotte Daniels is an amateur astronomer, astrophotographer and journalist

What you'll need

- ▶ An astrophotography planning app, such as PhotoPills or The Photographer's Ephemeris (TPE)
- ▶ A DSLR with kit lens (ideally greater than 75mm focal length)
- ▶ Sturdy tripod
- ▶ Memory cards and spare battery
- ▶ Intervalometer
- ▶ Photo-processing software

ALL PICTURES: CHARLOTTE DANIELS

Step by step


D 142° ∆ 13°
Moon
22:30
23
22
SE
24h
2025
10 Jul
22:32
NAUTICAL TWILIGHT

Step 1

Plan your shot during the daytime, by heading to your chosen location with a planning app. Many, including the TPE app on iOS, now have an augmented-reality feature that overlays the Moon's trajectory and allows you to see exactly where it will rise.

Step 2

Be sure to arrive back at your location at least 30 minutes before the moonrise time to capture your foreground shot (the sky will be too bright once it's risen). Take a few shots at different exposures, apertures and ISOs, so you have options later.

SHOOT
DELAY LONG INTVL N
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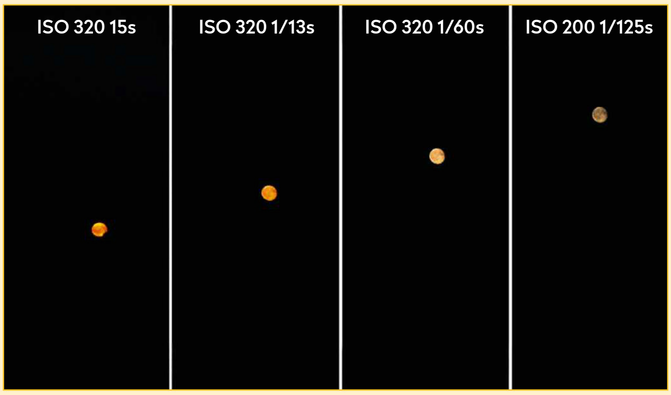
TIMER START/STOP
LOCK
MENU
INFO
Canon

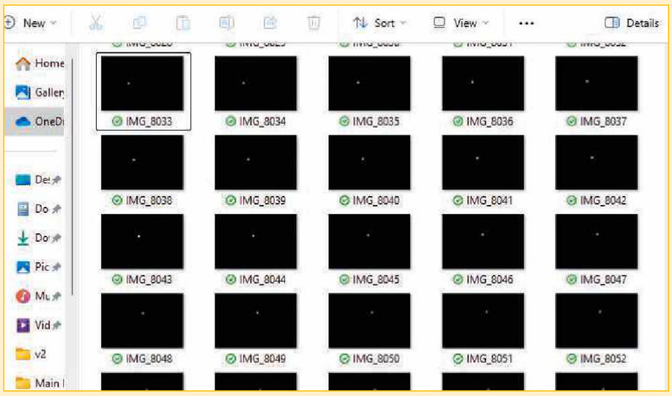
Step 3

As soon as the Moon glow appears above the horizon, set your intervalometer. A 30-second interval is a good starting point – you can always discard frames later to fine-tune the final effect. Start with longer exposures while the Moon is low.


ISO 320 15s
ISO 320 1/13s
ISO 320 1/60s
ISO 200 1/125s

Step 4

As the Moon continues to rise, adjust your settings. Reduce your exposure time and ISO, plus increase your aperture once the Moon has moved further from the dense atmosphere near the horizon. Take care not to shift the view as you change settings.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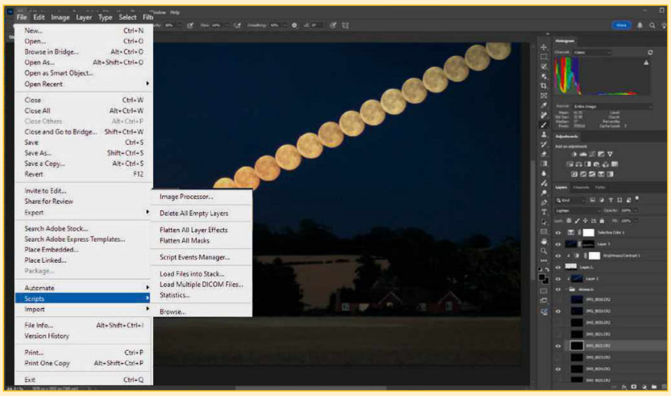
IMG_8052

Step 5

Take as many Moon shots as you like. We like to capture the journey across the entire frame to show its trajectory. For our final shots, we used ISO 200, f/11 and a shutter speed 1/125s to keep the Moon as sharp as possible.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Open As...
Open as Smart Object...
Open Recent
Close
Close All
Close and Go to Bridge...
Save
Save As...
Save a Copy...
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Invite to Edit...
Share for Review
Export
Search Adobe Stock...
Place Embedded...
Place Linked...
Package...
Automate
Scripts
Import
File Info...
Version History
Print...
Print One Copy
Exit
Image Processor...
Delete All Empty Layers
Flatten All Layer Effects
Flatten All Masks
Script Events Manager...
Load Files into Stack...
Load Multiple DICOM Files...
Statistics...
Browse...

Step 6

Process your shots with software like Photoshop or Lightroom. Lightroom lets you batch-process your Moon frames and adjust your foreground before blending. We opened our Moon images as a layer stack before changing the layer mode to 'Lighten'.

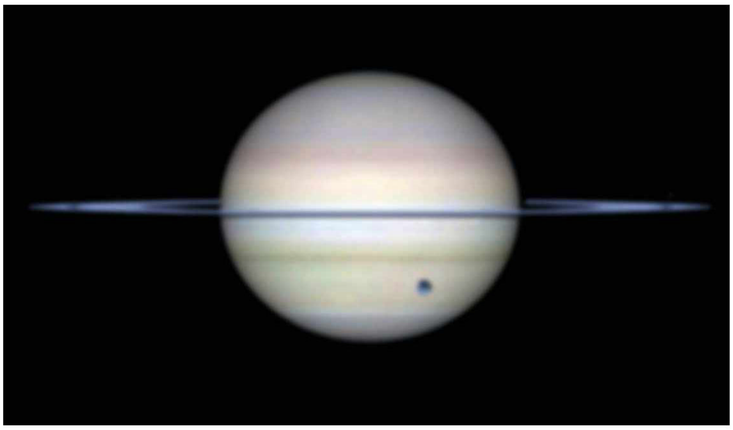
Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Last chance for Titan transits

It'll be 13 years before Titan crosses Saturn again. Here's how to grab shots of it now

In recent months, we've highlighted how Titan and its shadow have been passing across Saturn's disc, rare events that happen around Saturn's equinox. That's when the planet's apparent tilt angle makes it appear sideways-on to the Sun (and to us), bringing Titan into play. A lot of the early crossings that resulted were compromised by bad weather, poor seeing conditions and unfavourable timings, but now there's some good news – and some bad.



▲ Time's running out to catch Titan crossing Saturn and glimpse the planet's razor-thin rings

The good news? Titan will be transiting Saturn a couple of times each month from October 2025 through to January 2026, and many of these events will be well-timed for UK viewing. The bad news is that – as conditions for these transits are right only every 15 years or so – after February 2026, the next opportunity won't come until summer 2038.

It's also worth noting that, from early October, the position of the Sun as seen from Saturn is sufficiently south that Titan's shadow misses the planet altogether, which means Titan shadow transits are already off the table until 2038.

Bonus skinny rings

It's not all over, though. Back in March, Earth witnessed a Saturn ring plane crossing, though the planet appeared too close to the Sun for this to be seen. Saturn's equinox in May 2025 meant that, from Saturn, the Sun appeared on the planet's equatorial plane. The famous rings are also on this plane, so at the time the ring shadows on the planet's globe appeared very thin.

Now, as Saturn moves away from equinox, from the planet's perspective the Sun is slowly climbing higher in its southern sky. But from Earth we'll still see the rings go almost edge-on between 10 November and 7 December. During this time, Saturn appears tilted towards Earth by less than half a degree (its southern pole being slightly tilted towards us). This will make the rings appear extremely thin. Another big plus is that the more southerly altitude of the Sun from Saturn means the ring shadows will be more pronounced and easier to see than they were back in March.

Dates for your diary

There are two Titan transits visible this month, on 6 October and 21 October. Of course, this means there will be two corresponding intermediate dates when Titan will be on the far side of Saturn, potentially being eclipsed by Saturn's shadow and occulted by its globe. Those are on 13 October and 29 October, and are just as interesting to observe and record. See page 46 for all the precise timings.

Titan's relatively slow pace, plus the fact that it appears dark and large against Saturn's globe, work in our favour. However, we need to take any favours that nature can give us. Capturing these transits is no easy task, and exceptionally steady seeing conditions are essential.

Tenacity and patience are the name of the game, but as time is now running out for this rare phenomenon, we recommend putting the events in your observing calendar so you don't forget. Let's hope that the weather cooperates!

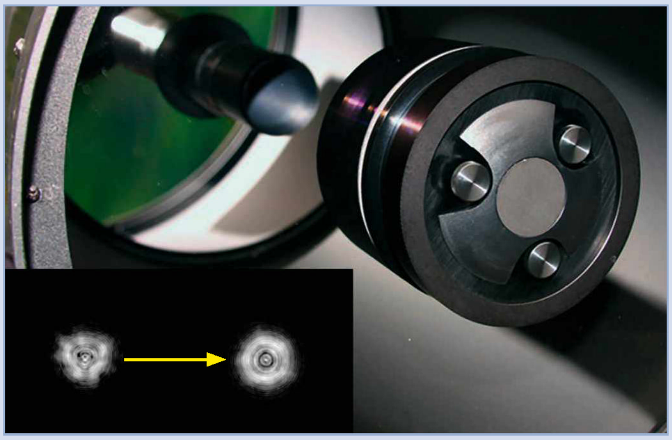
Equipment: Planetary imaging setup

✉ **Send your images to:**
gallery@skyatnightmagazine.com

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

ALL PICTURES: PETE LAWRENCE

Step by step



STEP 1

A planetary imaging setup is a must, along with practice imaging Saturn and Titan as often as conditions allow. Your telescope should be properly collimated; follow manufacturer's guidance for your particular scope and, ideally, check collimation with a 'star test' on a star near Saturn before every imaging session.

STEP 2

We'd usually recommend imaging planets when they're close to highest altitude (due south), but Titan event timings will almost certainly mess this up. Use planetarium software to check where the planet will be relative to the horizon. You don't want Saturn moving behind a tree or house at the critical moment!

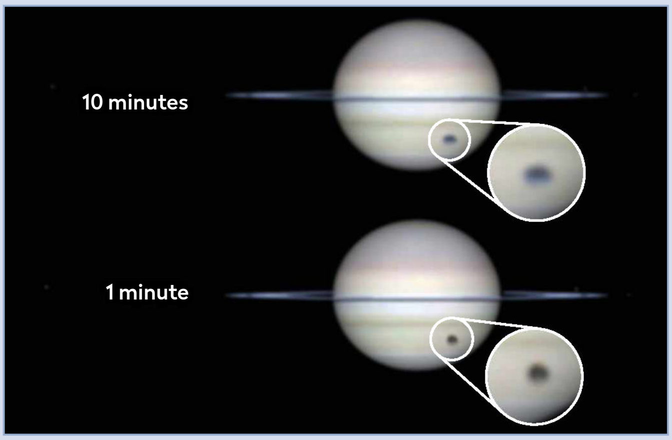
STEP 3

Work out a decent image scale for your setup. Ideally, aim for an effective focal ratio 5–7 times the size of your camera's pixels in microns: 5 for poor seeing, 7 for good. An optical amplifier such as a Barlow or Powermate can be used to achieve this. Practise with the final setup to avoid unexpected surprises.

Atmospheric
dispersion
corrector

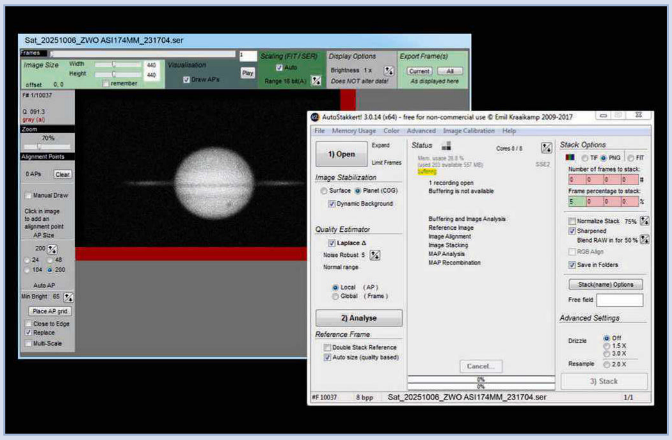
STEP 4

Consider what camera type to use. While a mono high-frame-rate camera offers precision, for a 'pretty' result you'll typically have to image through separate red, green and blue filters. One-shot-colour cameras are simpler, but need an atmospheric dispersion corrector to avoid colour fringing made worse by low altitude.


10 minutes
1 minute

STEP 5

Titan moves relatively slowly across Saturn's disc, but exposures using a high-frame-rate camera should still be kept short to avoid motion blur (see our example above). Aim to complete one full capture set (RGB exposures for mono, or a single colour run for a one-shot-colour camera) in under 120 seconds.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AutoStakkert! 3.0.14 (x64) - free for non-commercial use © Emil Kraaikamp 2009-2017
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1) Open
Image Stabilization
Surface
Planet (COG)
Dynamic Background
Quality Estimator
Laplace Δ
Noise Robust 5
Local (AP)
Global (Frame)
2) Analyse
Reference Frame
Double Stack Reference
Auto size (quality based)
Status
1 recording open
Buffering is not available
Stack Options
Number of frames to stack:
Frame percentage to stack:
Normalize Stack 75%
Sharpened
Save in Folders
Advanced Settings
Drizzle
Resample
3) Stack
Cancel...

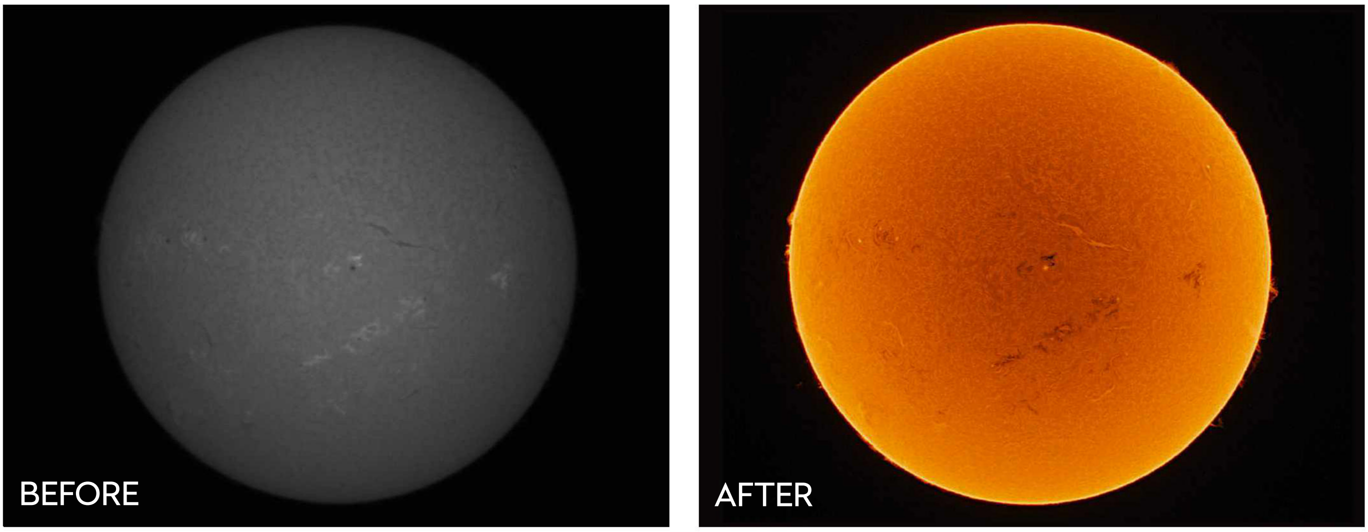
STEP 6

Titan is tricky to capture in poor seeing. A mono or IR-sensitive colour camera with an IR-pass filter can stabilise the seeing, as infrared's longer wavelength is less affected by our turbulent atmosphere. Once your session is over, process your results with registration-stacking software, such as AutoStakkert!

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Turn mono Sun shots into fiery colour

A simple, free technique to take your solar images from greyscale to gold



▲ **A monochrome camera paired with solar hydrogen-alpha optics reveals intricate features such as prominences and flares (left). With free tools ImPPG and GIMP, it's easy to boost the drama and transform your image into the familiar yellow-orange hues of our star (right)**

ALL PICTURES: IVANA PERANIC

As the latest solar cycle reached its peak, many amateur imagers took their first solar snaps, capturing fascinating and dynamic activity on the Sun's surface. One popular method is to use a solar hydrogen alpha filter such as an etalon that, if coupled with a monochrome camera, unveils the Sun's chromosphere and delicate details such as prominences and flares. Once you've teased out these features through processing, you can easily convert your monochrome images into the familiar red-orange hues of our nearest star. Here we'll walk you through the two key techniques – inverting and then colourising – you can use to achieve this.

We'll use ImPPG and GIMP, two capable image-manipulation programs you can download for free. ImPPG handles the inversion process, but note that it works only on PCs and with monochrome image files from monochrome cameras. GIMP is an image-editing program not unlike Photoshop. You can use this to convert your image from monochrome to colour.

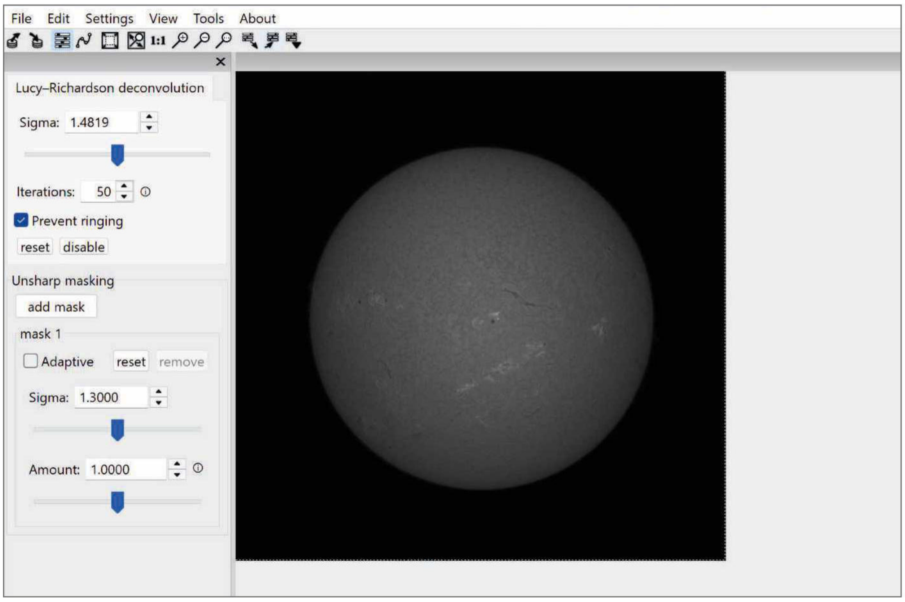
Inverting a solar image simply means assigning the white areas to black, and the black areas to white, much like a negative, while keeping the background black. While it's certainly a matter of taste, this technique boosts prominences and flares on the limb in a single capture, and helps surface details to pop.

Sharpen, invert, colour

We started by opening ImPPG and selecting our start image (click File › Open), made from 3,500 frames that we'd stacked in AutoStakkert! (another free program). ImPPG automatically applies a default level of sharpening to a small square section in the middle of your image; to apply this and any further changes to your whole image, select the square icon in the top horizontal menu (see Screenshot 1).

ImPPG uses the Lucy–Richardson deconvolution method for sharpening: you can adjust the level of sharpening by pulling the slider on the left-hand side tab. If your image is showing a halo-like effect on the edges of the solar disc due to the extreme contrast between the Sun and the black background, you can also tick the 'Prevent ringing' option underneath to reduce this (Screenshot 1).

Once happy with the sharpness, invert your image by selecting the 'Tone curve' icon in the header menu (Screenshot 2). ImPPG will now show a separate window with a curve that runs diagonally from the lower-left (darkest pixels) to the upper-right corner (lightest pixels). Clicking the 'Inv' button creates a simple negative image which you can then fine-tune. Be aware that it's easy to mistakenly make the background white. To keep the


File Edit Settings View Tools About
Lucy–Richardson deconvolution
reset disable
Unsharp masking
add mask
mask 1
reset remove

Sigma: 1.4819

Iterations: 50

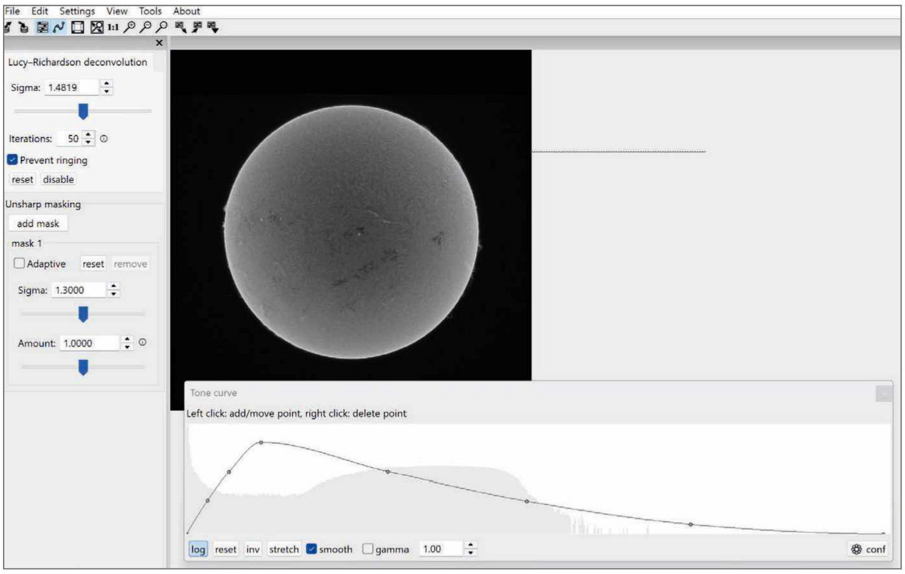
☑ Prevent ringing

☐ Adaptive

Sigma: 1.3000

Amount: 1.0000

▲ **Screenshot 1: with your image open in ImPPG, apply Lucy–Richardson deconvolution to sharpen and denoise, then fine-tune with the sliders. Tick 'Prevent ringing' if needed**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Sigma: 1.4819

Iterations: 50

☑ Prevent ringing

☐ Adaptive

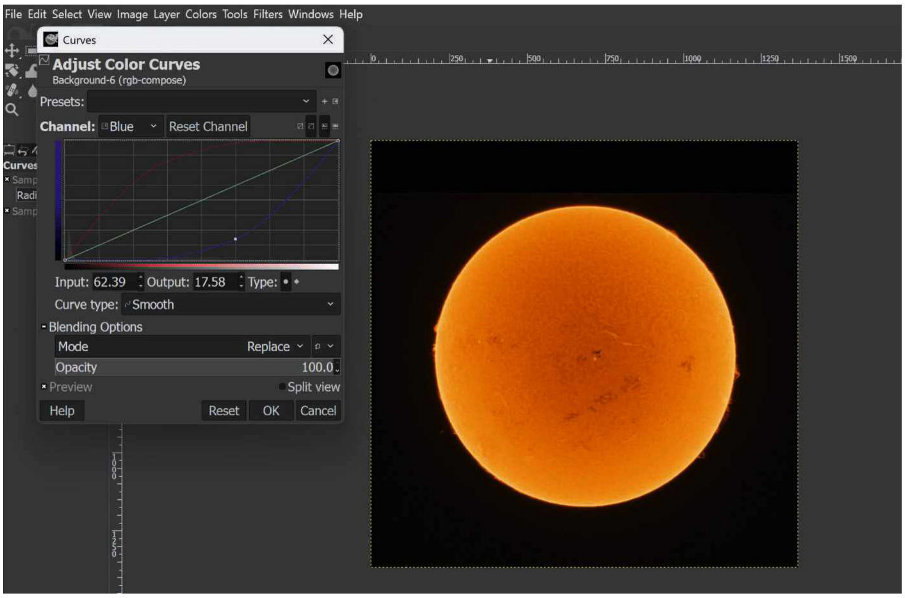
Sigma: 1.3000

Amount: 1.0000

Left click: add/move point, right click: delete point

☑ smooth ☐ gamma 1.00

▲ **Screenshot 2: click 'Tone curve' to open a curve that ranges from the darkest pixels to the lightest. Click 'Inv' to create a simple negative. Be sure to keep the background black**


File Edit Select View Image Layer Colors Tools Filters Windows Help
Curves
Adjust Color Curves
Background-6 (rgb-compose)
Reset Channel
Blending Options
Preview
Split view
Help
Reset
OK
Cancel

Presets:

Channel: Blue

Input: 62.39 Output: 17.58 Type:

Curve type: Smooth

Mode Replace

Opacity 100.0

▲ **Screenshot 3: in GIMP, use 'Curves' to adjust each RGB channel and create a sunny soft yellow and orange colour for our star. Don't overdo it – you'll oversaturate your image**

3 QUICK TIPS

1. If your image has uneven gradients, take flat frames to smooth these out.

2. After colouring with GIMP, merge the layers by clicking Image › Flatten Image before saving.

3. If posting to social media, click Image › Scale Image. Scaling to 2,048 pixels on the longest edge reduces compression.

background black, create a curve like the one pictured, which slopes upwards on the left side of the histogram.

Every point on the curve controls a different aspect of the image, from the brightness of prominences on the lower left of the curve, to surface contrast on the right. Ideally, your adjustments should create a harmonious image without overblown or overly contrasting areas. When you're satisfied, click File › Save.

Adding colour to your inverted image brings a lovely aesthetic dimension. To do this, open your image in GIMP and click Colors on the header menu, then Components › Compose. Under Compose, select 'RGB' for your colour model. This creates a new greyscale image made of three channels: red, green and blue.

Return to the Colors tab and this time select 'Curves'. This opens a separate tab that adjusts each colour layer individually. To achieve the soft yellow and orange hue that we associate with the Sun, first click 'Value' and select the red channel. Pull the red diagonal line away from the middle, softly bending the curve towards the upper-left corner. Change the value to the blue channel and pull the middle of the blue line in the opposite direction, towards the lower-right corner (Screenshot 3).

Adding colour to the image may reduce contrast and visibility of finer details, so be careful not to stretch the curve too far and oversaturate the image. Under the Colors tab, you can make any final adjustments to boost the contrast and saturation, as well as the highlights and overall brightness of your image.

Ivana Peranic is a cellist by day and astrophotographer by night, based in Brighton, UK

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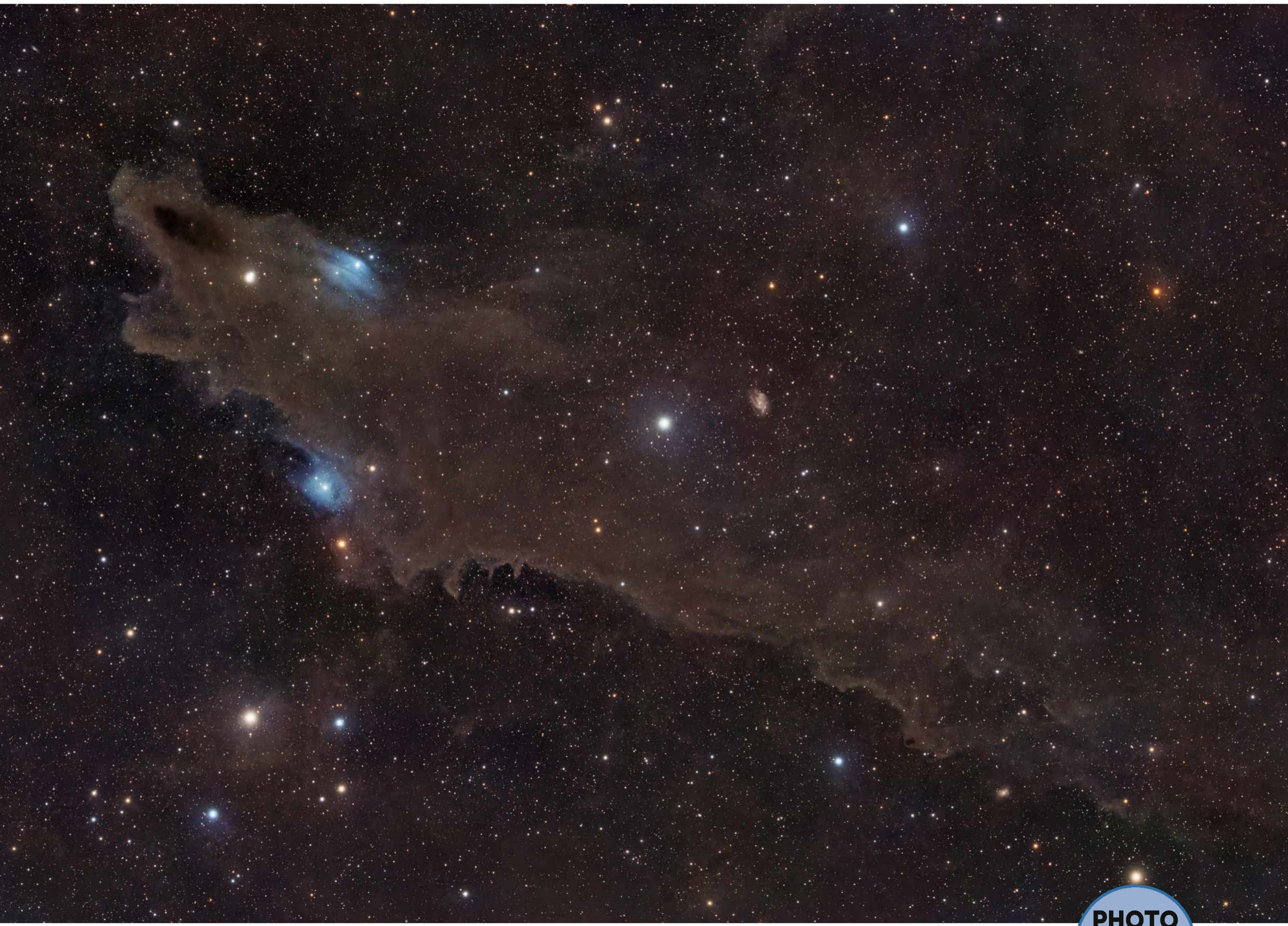


PHOTO OF THE MONTH

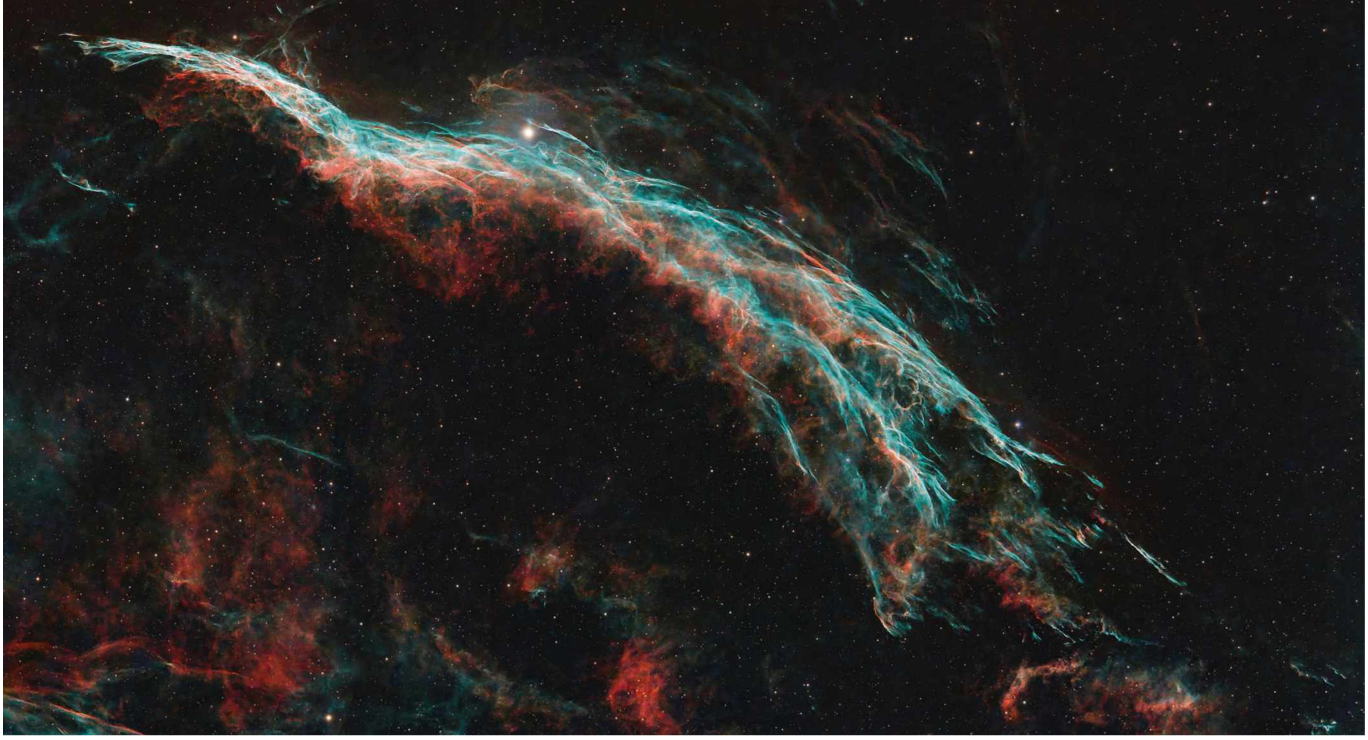
△ The Dark Shark Nebula

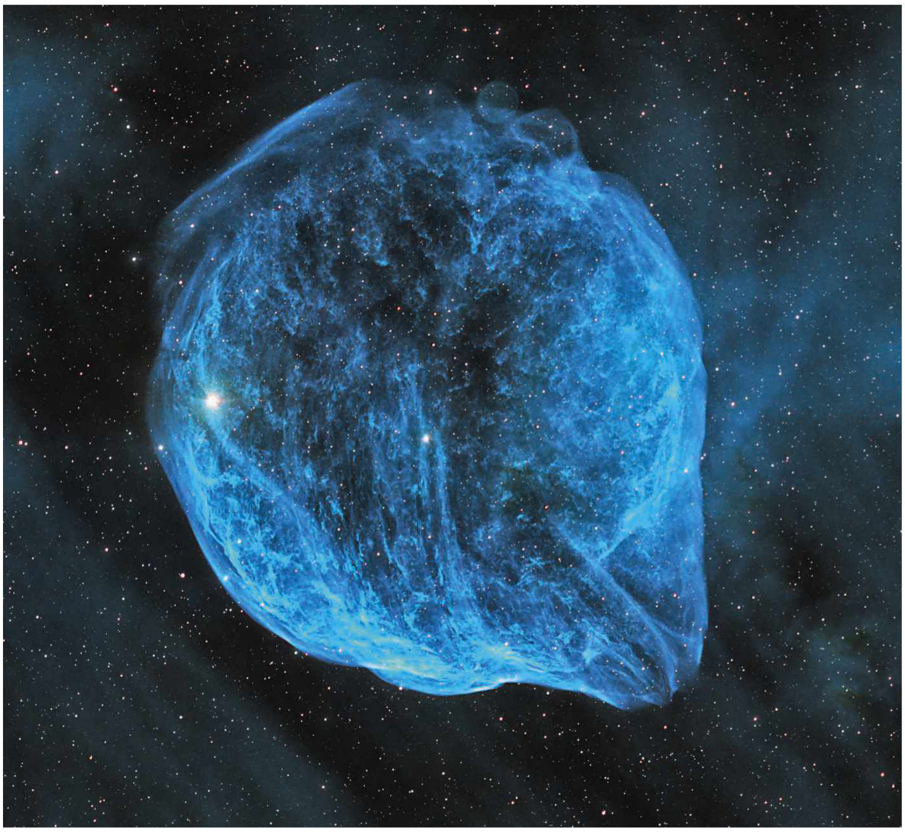
Ron Brecher, Guelph, Ontario, Canada, 23–30 July 2025

Ron says: "Many celestial objects resemble animals, but perhaps none more so than the Dark Shark. Its snout, jaws, eye, dorsal fin and tail are all obvious in this sea of dust, gas and stars. It was great fun teasing out the details."

Equipment: QHYCCD QHY168C camera, Sky-Watcher Esprit 70EDX refractor, Sky-Watcher Wave 150i mount **Exposure:** 287x 300" **Software:** PixInsight

Ron's top tips: "Dark nebulae can be tricky to process. It's important to make your image bright and boost contrast, but don't 'overcook' it. I worked with masks to enhance the spiral galaxy on the Shark's back and the blue van den Bergh nebulae. I decided not to suppress the glow around the brightest stars, which gives a dusty, hazy overall feel to the photo."





△ The Western Veil Nebula

David Hugill, Cirencester, Gloucestershire, UK, 4 July 2025

David says: "This is one of my favourite targets for the short summer nights. I used an Optolong dual-band filter to capture Ha and OIII together."

Equipment: ZWO ASI585MC Pro camera, Stella-Mira 90mm ED refractor, ZWO AM3 mount **Exposure:** 70x 120" **Software:** PixInsight

◁ The Dolphin Head Nebula

Fernando Menezes, Munhoz, Minas Gerais, Brazil, 30 September 2024–11 January 2025

Fernando says: "This passes high overhead during Brazil's long rainy season, so it's difficult to achieve. After four years, I finally managed it!"

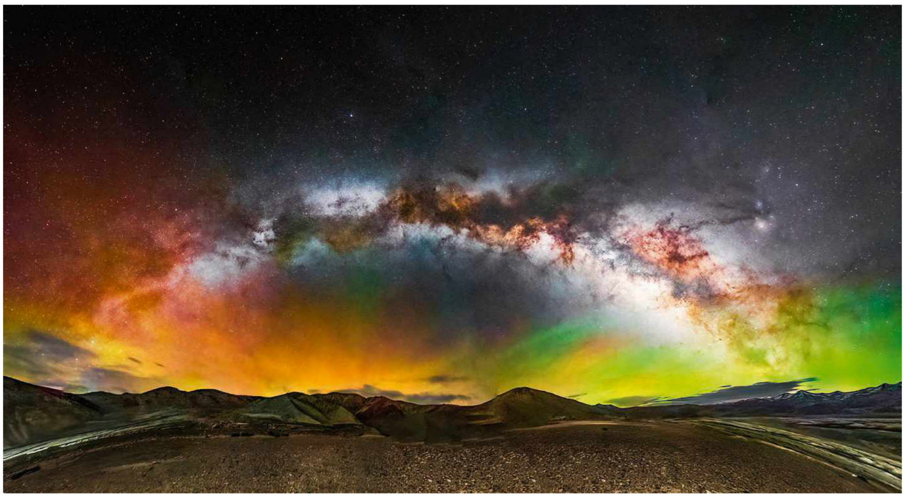
Equipment: ZWO ASI6200MM camera, Sky-Watcher Esprit 150ED refractor, Software Bisque Paramount MX+ mount **Exposure:** Ha 40x 500", OIII 123x 500", SII 13x 500" **Software:** PixInsight, Photoshop

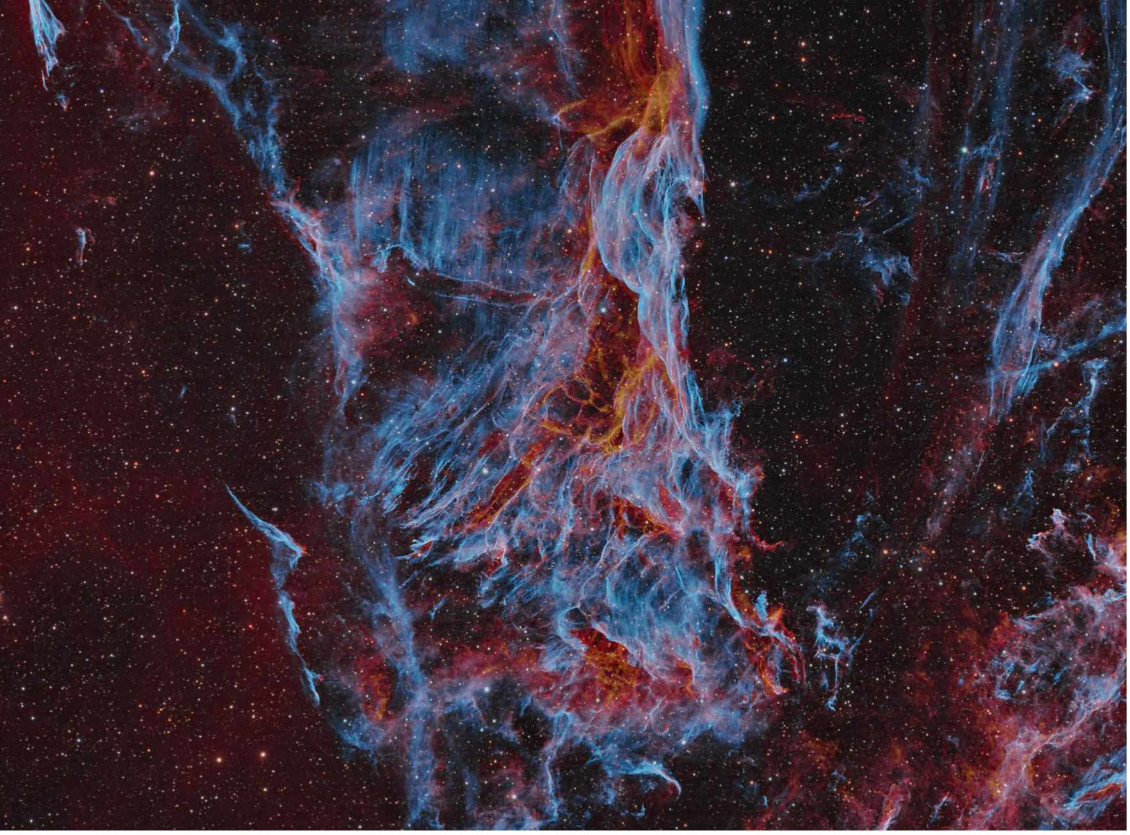
The Milky Way ▷

AJ Singh, Tso Kar, Ladakh, India, 26 June 2025

AJ says: "This was my first visit to Tso Kar lake. Capturing panels to create panoramic images is always hectic, but the results are fruitful."

Equipment: Canon EOS R camera, Canon RF 16mm lens, iOptron SkyTracker mount **Exposure:** Sky 12x 180", foreground 16x 90" **Software:** Lightroom, Photoshop





◁ Fleming's Triangle

Kimberly Sibbald, Alberta, Canada, 6 July and 3–26 September 2024

Kimberly says: "Discovered by Williamina Fleming, this Veil Nebula feature is usually called Pickering's Triangle after her male supervisor."

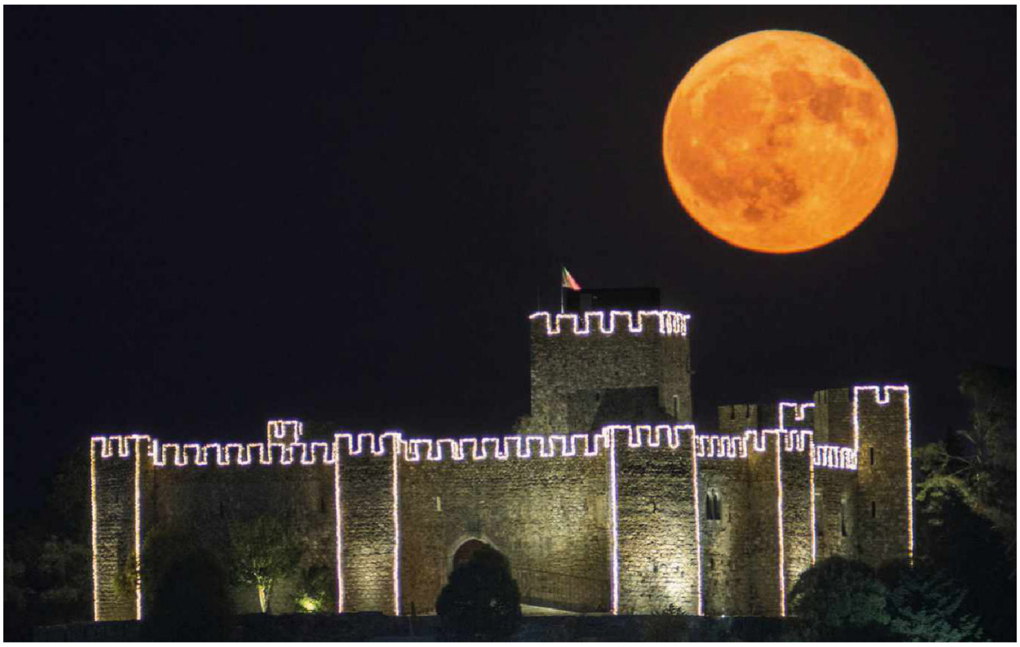
Equipment: ZWO ASI2600MM Pro camera, SharpStar AL-140PH refractor, Mesu 200 MKII mount
Exposure: R 15x 120", G 15x 120", B 17x 120", Ha 21x 20', OIII 27x 20', SII 21x 20'
Software: PixInsight, Photoshop

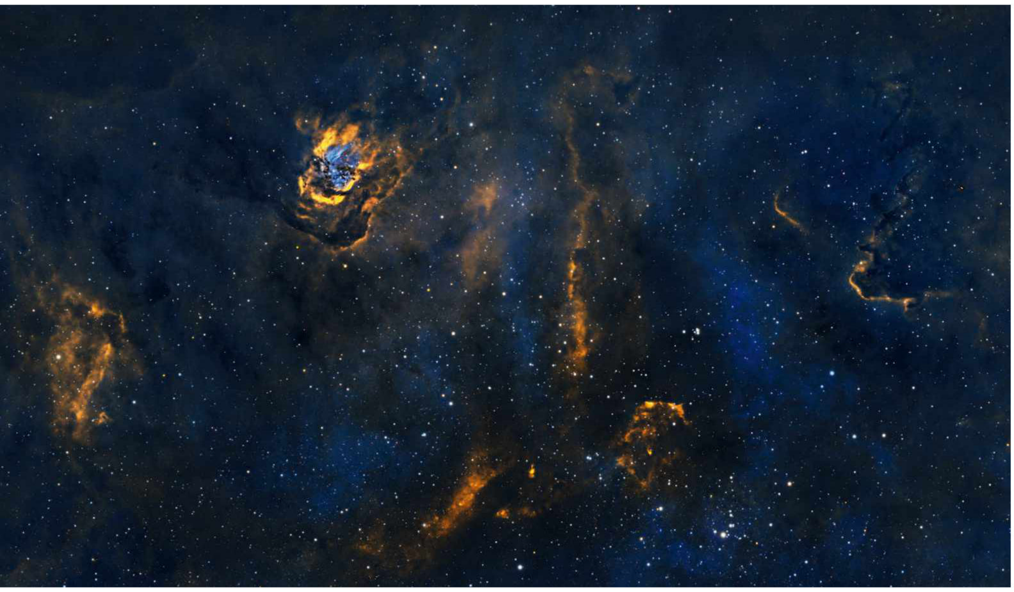
Sturgeon Moon over the Castle of Pombal ▷

Rui Santos, Pombal, Leiria, Portugal, 9 August 2025

Rui says: "I stepped out of my comfort zone to frame the Moon in a new location. I now know little can go wrong, except the whims of the weather!"

Equipment: Sony Alpha A6000 camera, Lightdow 420–800mm lens, Geekoto AT24Pro Dreamer tripod
Exposure: ISO 1250 f/8, 1"
Software: Lightroom, Photoshop



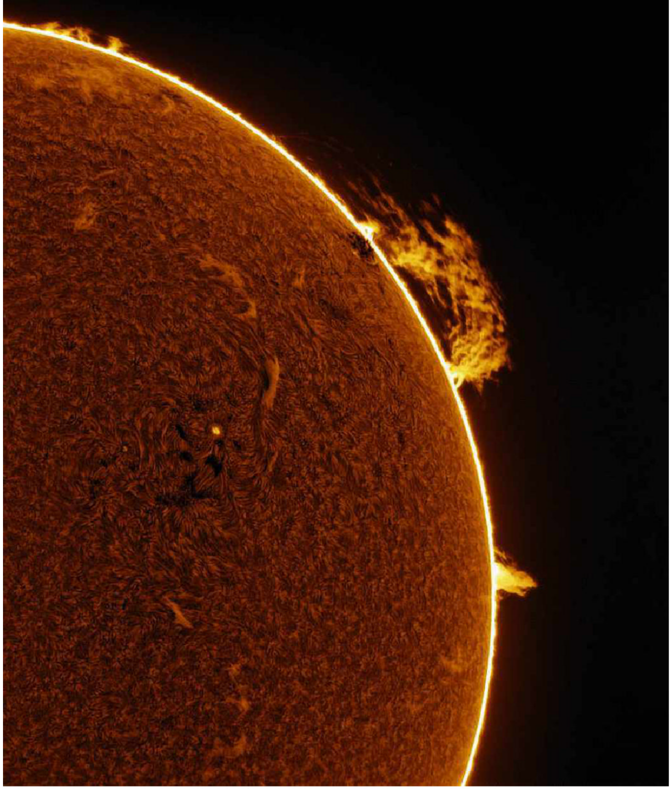


◁ The Serpent Nebula

Patrick Cosgrove, Honeoye Falls, New York, USA, 22–23 June 2025

Patrick says: "I was perusing the Sharpless catalogue for a nice target for my first narrowband effort from my new backyard observatory, when I came across this fascinating nebula."

Equipment: ZWO ASI2600MM Pro camera, Astro-Physics StarFire 130 EDT refractor, custom steel pier mount
Exposure: Ha 36x 300", OIII 35x 300", SII 36x 300"
Software: PixInsight, Photoshop



◁ Solar prominence

Kyle Western, Liverpool, UK, 2 July 2025

Kyle says: "This image shows a striking solar prominence. Surface detail and motion along the solar limb always make the Sun a compelling subject to photograph."

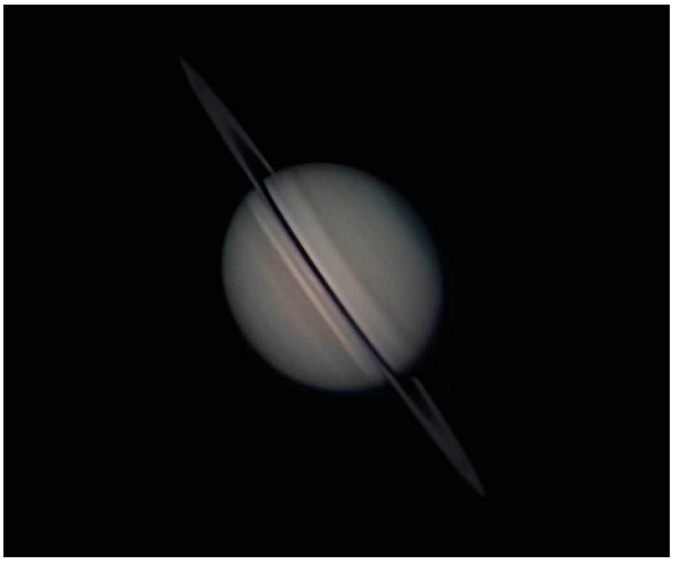
Equipment: ZWO ASI174MM camera, Lunt LS60MT refractor, Sky-Watcher HEQ5 Pro mount
Exposure: Best 10 per cent of 4,285 frames, 7ms per frame
Software: AutoStakkert!, PixInsight, ImPPG

Saturn ▷

Philip Michel, St Albans, Hertfordshire, UK, 6 August 2025

Philip says: "Saturn is my favourite planet, but it can be difficult to image clearly, so I was delighted with the clarity of the narrow rings and atmospheric features."

Equipment: ZWO ASI290MC camera, Sky-Watcher Skyliner 300P Dobsonian
Exposure: Best 33 per cent of 6,000 frames, 25ms per frame
Software: AutoStakkert!, RegiStax, Topaz DeNoise

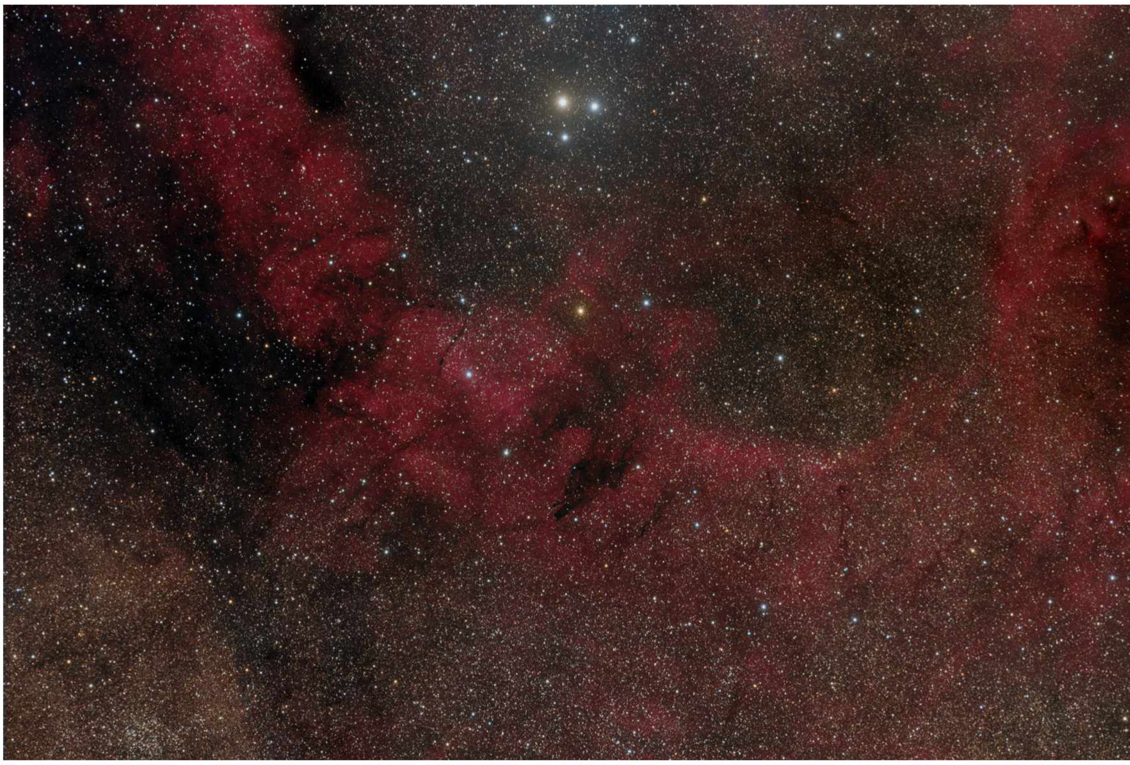


Dark nebula HMSTG877 ▷

Dan Crowson, captured remotely via Telescope Live, Heaven's Mirror Observatory, New South Wales, Australia, March–August 2024

Dan says: "This is a target I always wanted to image, but it's too low from Missouri, USA. Telescope Live enabled me to capture it using a telescope in Australia."

Equipment: QHYCCD QHY600M camera, Takahashi FSQ-106ED refractor, Software Bisque Paramount MX+ mount
Exposure: L 16x 300", R 40x 300", G 32x 300", B 23x 300", Ha 154x 300"
Software: CCDStack, PixInsight



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NOVAStar
3mm LONG EYE-
5mm LON
6mm LON
12.5mm LONG
9mm
14.5mm LONG
18mm LONG EYE-RELIEF

86

Looking good: could NOVAStar's bargain eyepieces give your views a serious upgrade? We find out

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AND MERCURY REMASTERED
STAR ANALYSER 200-F

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HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★☆ Very good
★★★☆☆ Good ★★☆☆☆ Average ★☆☆☆☆ Poor/avoid

Our experts review the latest kit

FIRST LIGHT

NOVAStar long eye relief planetary eyepieces

Striking views at a pocket-friendly price point? Seeing is believing…

WORDS: CHRIS GRIMMER

Many of us remember our first telescope purchase. Often it was part of a set and came with basic accessories, including a couple of eyepieces, one low power and one higher. These are great in the early days, but before long your thoughts turn to upgrades and better fields of view. If you're ready to take that step up, read on as we look at the NOVAStar long eye relief (LER) planetary eyepieces range, which claims to deliver exceptional views at a very reasonable price point.

The 'planetary' badge means that there are no low-power or particularly long focal lengths available in the LER collection, with focal lengths starting at a respectable 18mm before stepping up through the powers to a punchy 3mm. Each offers a 55° field of view, marginally wider than the typical 52° found in most Plössl eyepieces.

There isn't an option to purchase the seven eyepieces as a set in an eyepieces case; instead, we received them individually wrapped in boxes. Unpacking them, our first impressions were excellent: each eyepiece felt robust and well-constructed.

As the first nights of late summer astronomical darkness arrived, we set up our 200mm reflector and began exploring the dark skies. It immediately became apparent that a standout feature of the NOVAStar eyepieces is the exceptional sharpness each offers. Throughout the range, stars consistently appeared as distinct pinpoints of light, with a clarity often reserved for more expensive equipment. This sharpness was particularly noticeable when observing double-star targets, where the ability to distinguish between closely spaced objects is crucial.

Let's get testing

Starting with the 18mm eyepiece in the focuser, we were easily able to perform a three-star alignment before commencing our tour of the summer skies. We could clearly define the four individual stars within the well-known Double Double star, Epsilon Lyrae. The views continued to excite as we tested each focal length in turn, culminating in a cracking 333x magnification using the 3mm eyepiece.

At this extremely high power, the four sharp and well-defined stars clearly stood apart, with black sky ▶

VITAL STATS

- **Price** £59 each
- **Focal lengths** 3mm, 5mm, 6mm, 9mm, 12.5mm, 14.5mm, 18mm
- **Lens design** Planetary
- **Apparent field of view** 55°
- **Eye relief** 20mm
- **Optical elements** Seven elements in four groups
- **Barrel size** 1.25-inch
- **Extras** Cleaning cloth
- **Weight** 200g–350g
- **Supplier** 365 Astronomy
- **Tel** 020 33 845 187
- **www.**365astronomy.com

Flat field, fine focus

The NOVAStar LER eyepiece design boasts a fully multi-coated optical system that contains seven elements in four groups, ensuring excellent light transmission, contrast and colour control. Throughout the range, we appreciated the reassuringly consistent flat field of view, with no curvature or astigmatism to be seen.

Each eyepiece also features a matt-black internal construction and lens edges, designed to further enhance views by minimising internal reflections. In use, we enjoyed a clean, sharp edge, even when we placed a bright, twinkling Vega on the periphery or just outside of the field of view.

NOVAStar claims that every eyepiece in the range is parfocal, allowing seamless switching between focal lengths without the need to refocus. This is a popular feature for outreach events, when astronomers are constantly switching between eyepieces, targets and eyesights. In practice, we found that while the focus point was close as we swapped out each eyepiece, a small amount of refocusing was required each time for perfect views.

NOVAStar
6mm
LONG EYE

ALL PHOTOS: @THESHED_PHOTOSTUDIO

SCALE

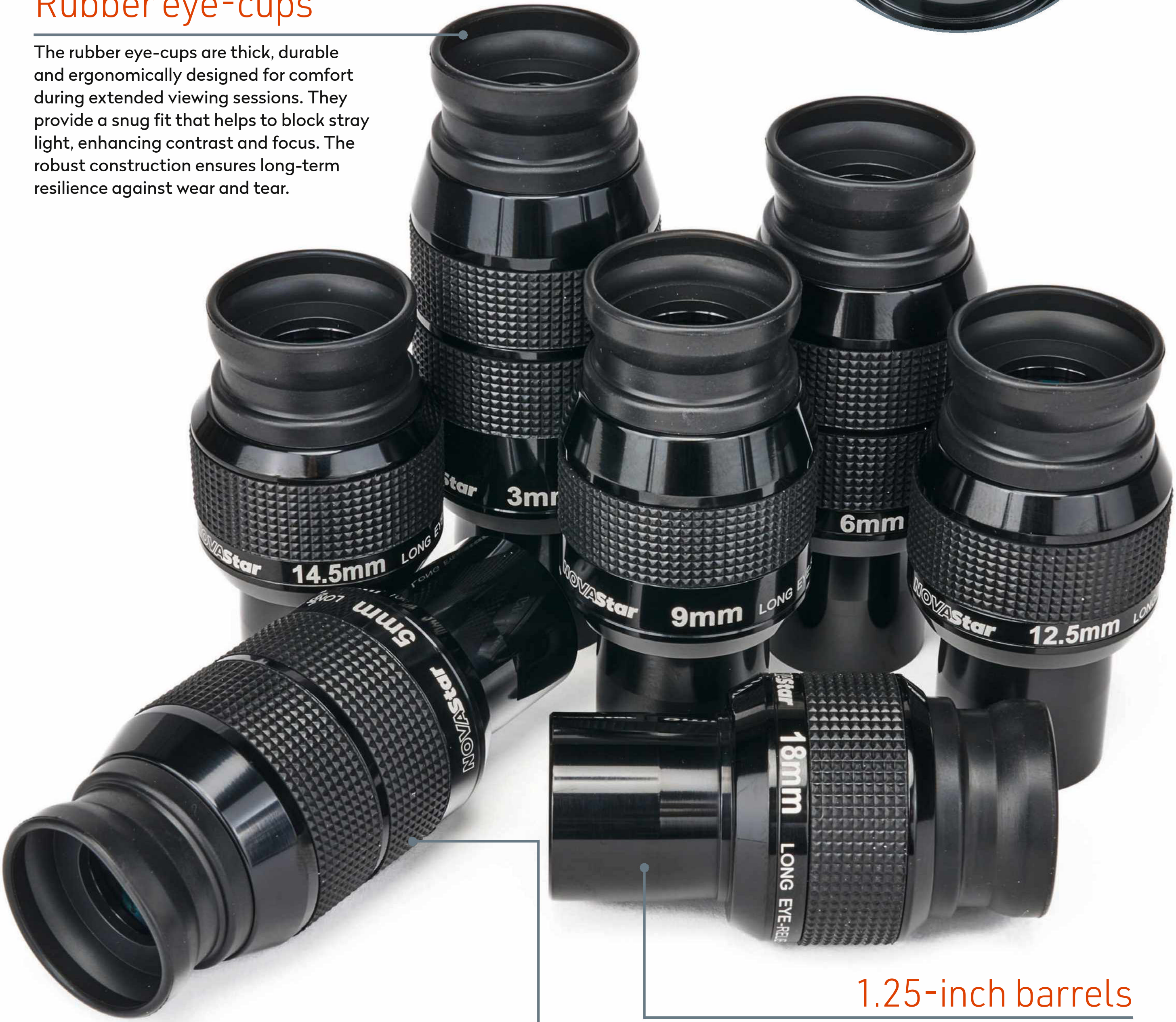
NOVAStar 9mm
NOVAStar 18mm LONG EYE

Filter screw threads

Each eyepiece includes a 1.25-inch standard filter thread, allowing you to attach a wide range of astronomical accessories to enhance your observing session, including planetary, lunar or light-pollution filters. This added versatility means you can tailor your accessories to suit your target, further boosting contrast and details.

Rubber eye-cups

The rubber eye-cups are thick, durable and ergonomically designed for comfort during extended viewing sessions. They provide a snug fit that helps to block stray light, enhancing contrast and focus. The robust construction ensures long-term resilience against wear and tear.



Ergonomic lightweight design

Each eyepiece features an ergonomically designed body that enhances comfort and usability during long observing sessions. The thick rubber grip provides a secure, non-slip hold, even in our cold and damp climate, which provides a reassuring sense of security when handling and adjusting the eyepiece.

1.25-inch barrels

The 1.25-inch barrel of each eyepiece is designed to fit standard telescopes. The barrel is precision-machined for a snug, secure fit and smoothly transitions into and out of a 1.25-inch diagonal. This standard sizing ensures broad compatibility across most amateur telescopes, ensuring these eyepieces can remain part of your go-to accessories as other kit changes.

NOVAStar 12.5mm
3mm LONG EYE
FULLY MULTI

Dust caps

The NOVAStar LER eyepieces include durable, soft plastic dust caps for both ends, designed to protect the optics from dust, moisture and scratches during storage or transport. They fit snugly over the eyepiece barrel and rubber eye-cups, and ensure a secure seal without being difficult to remove, preserving optical performance.

NOVAStar 14.5mm

NOVAStar 3mm LONG EYE
NOVAStar 5mm LONG EYE
NOVAStar 6mm LONG EYE
NOVAStar 9mm LONG
NOVAStar 12.5mm LONG
NOVAStar 14.5mm
NOVAStar 18mm

▶ visible between, providing the cleanest view we've enjoyed of this formation. Views of the globular cluster in Hercules, M13, were equally spectacular, with many fine individual stars clearly speckled across the cluster. In fact, we experienced striking, distortion-free views from each of the LER eyepieces.

Many eyepieces on the market, especially those at the budget end, suffer from some form of optical distortion, such as chromatic aberration or field curvature. Particularly poor-quality examples can even discourage newcomers from pursuing this wonderful hobby, as the struggle to resolve details or find objects results in frustration and disappointment. This NOVAStar eyepiece collection, however, is impressively designed to minimise these issues. As an example, we found no colour fringing or discernible curvature even when placing a brighter star at the edge of the field of view. The 20mm eye relief proved comfortable and accurate across the range, with spectacle wearers in our party also enjoying the sharp, clear views.

But while the NOVAStar eyepieces do excel, there is an undeniable trade-off: the relatively narrow 55° field. This means that while each object in view is incredibly clear and detailed, the overall area that's visible at any one time is slightly limited. It also means that sweeping views of large star fields or extended objects – such as the Andromeda Galaxy, M31 – are restricted and may need to be viewed at less optimal power.

As our summer observing sessions reached their finale, we were left impressed. The NOVAStar LER eyepieces offer strikingly clear views, revealing fine details across a wide variety of astronomical targets, including clusters, deep-sky objects and the Moon. Whether you're just starting out or have years of experience behind the eyepiece, they're a worthwhile addition to any astronomer's kit.

KIT TO ADD

1. NOVAStar 1.25-inch diagonal

2. 1.25-inch lunar filter

3. Smartphone adaptor

VERDICT

Build & design	★★★★☆
Ease of use	★★★★★
Extras	★★★★☆
Eye relief	★★★★★
Optics	★★★★☆
OVERALL	★★★★☆

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Our experts review the latest kit

FIRST LIGHT

Sightron Infini D50 achromat telescope set

Big on old-school charm, this no-frills refractor delivers pure stargazing joy

WORDS: TIM JARDINE

VITAL STATS

- **Price** £389
- **Optics** Achromatic refractor
- **Aperture** 50mm
- **Focal length** 540mm, f/10.9
- **Focuser** Single-speed rack and pinion
- **Mount** Altazimuth
- **Extras** Star diagonal, 2x eyepieces, finder
- **Weight** 3kg
- **Supplier** First Light Optics
- **Email** questions@firstlightoptics.com
- **www.**firstlightoptics.com

The new Sightron Infini D50 set caught our eye as a budget, long-focal-ratio achromat in a market dominated by modern, short and fast refractors. Could this grab-and-go kit deliver high-contrast views for budding astronomers?

When our review package arrived, first impressions were – unsurprisingly for the price – that this is a basic, entry-level set. And to a certain degree, this is true. However, we soon discovered that there is more to Sightron's Infini D50 than meets the eye.

The manual altazimuth mount requires a modicum of assembly to attach the triangular spreader plate. Once that's in place, you'll notice that the central pillar can no longer be fully lowered, leaving a minimum tripod height of around 60cm. Each leg has two extensions and at maximum stretch the telescope sits 150cm from the ground.

The tripod section is constructed from aluminium, with plastic fittings making it lightweight and functional. We appreciated the small rubber caps at the ends of the legs to dampen vibrations and prevent the legs skidding on hard surfaces. That's a positive. The negative is that these can slip off during use and are particularly difficult to find in the dark. The mount feels sturdy and weighs around 500g, screwing onto the tripod via a standard 3/8-inch thread. The movement-control knobs are rubberised. In use, they're perfectly adequate, easy to use and capable of fine adjustments. Just note that using them does introduce significant vibration through the telescope and eyepiece.

The refractor itself is well constructed: the white tube is aluminium, as are most of the fittings except for the dual focusing knobs, which are 50mm in diameter and made of rigid plastic. The tube attaches to the mount via a single thumbscrew in a Vixen-style bracket, ensuring it's easy to set up, light to carry and highly portable.

Old-fashioned fun

While waiting for the long summer twilight to recede into darkness, we picked out a few daytime terrestrial targets for alignment practice, including a bird in a distant tree and a rooftop TV aerial. In much the same way that a familiar fragrance can transport you to times gone by, these simple views conjured up happy memories of hours spent, decades ago, ▶

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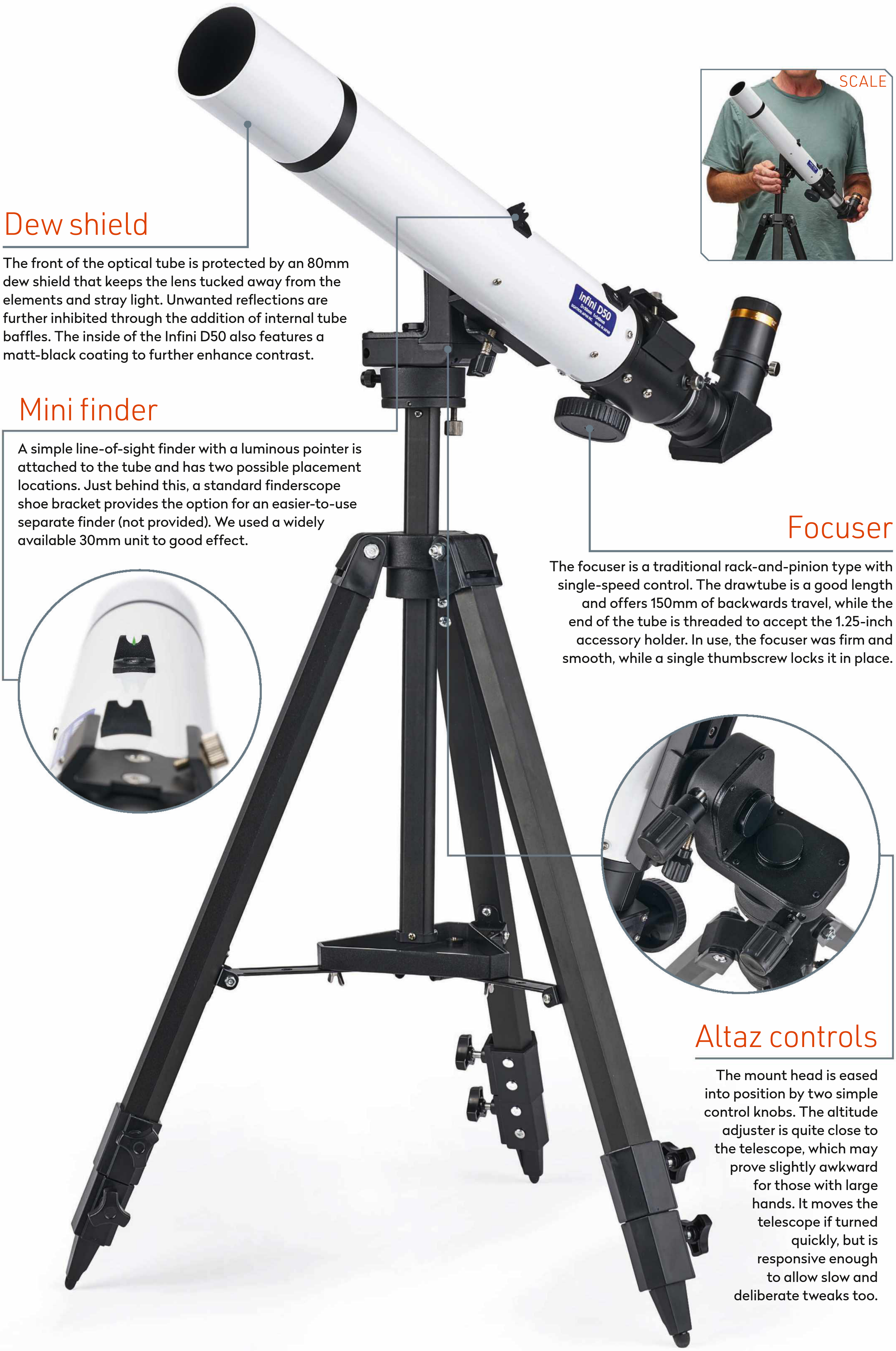
Quality 50mm achromat lens

Japanese telescope lenses have a reputation for excellence. Cue the 50mm achromatic objective lens in the Infini D50, which is multi-coated to reduce reflections and boost contrasts, with a relatively long focal length of 540mm.

We enjoyed good-quality star fields from this f/10.8 lens, tight and round, with a symmetrical airy disc at high magnification. Stars were sharp over most of the centre of both eyepieces, providing high-quality observing opportunities – and not just at night.

Using our own solar filter, we observed several sunspots in exquisite detail and even managed to photograph them using a phone holder on the eyepiece. On a 50%-illuminated Moon, a tour of the terminator revealed detail-rich views with almost zero colour fringing using the provided 23mm eyepiece.

The higher-magnification 10mm eyepiece helped to reveal the smaller Messier targets against a darker background, but both provided clear, high-contrast views. With our own 4.5mm eyepiece and clear views, we especially enjoyed observing all four stars in Epsilon Lyrae, the famous Double Double.



Dew shield

The front of the optical tube is protected by an 80mm dew shield that keeps the lens tucked away from the elements and stray light. Unwanted reflections are further inhibited through the addition of internal tube baffles. The inside of the Infini D50 also features a matt-black coating to further enhance contrast.

Mini finder

A simple line-of-sight finder with a luminous pointer is attached to the tube and has two possible placement locations. Just behind this, a standard finderscope shoe bracket provides the option for an easier-to-use separate finder (not provided). We used a widely available 30mm unit to good effect.

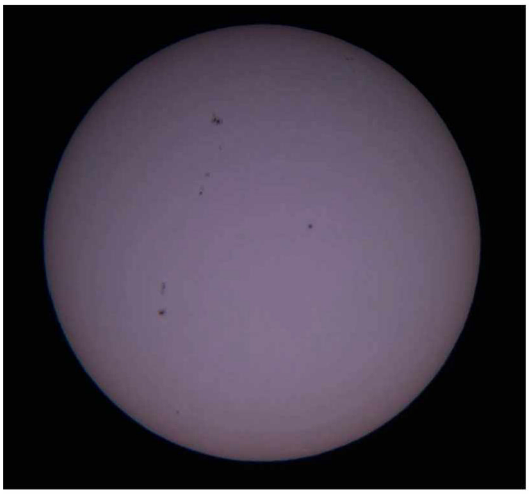
Focuser

The focuser is a traditional rack-and-pinion type with single-speed control. The drawtube is a good length and offers 150mm of backwards travel, while the end of the tube is threaded to accept the 1.25-inch accessory holder. In use, the focuser was firm and smooth, while a single thumbscrew locks it in place.

Altaz controls

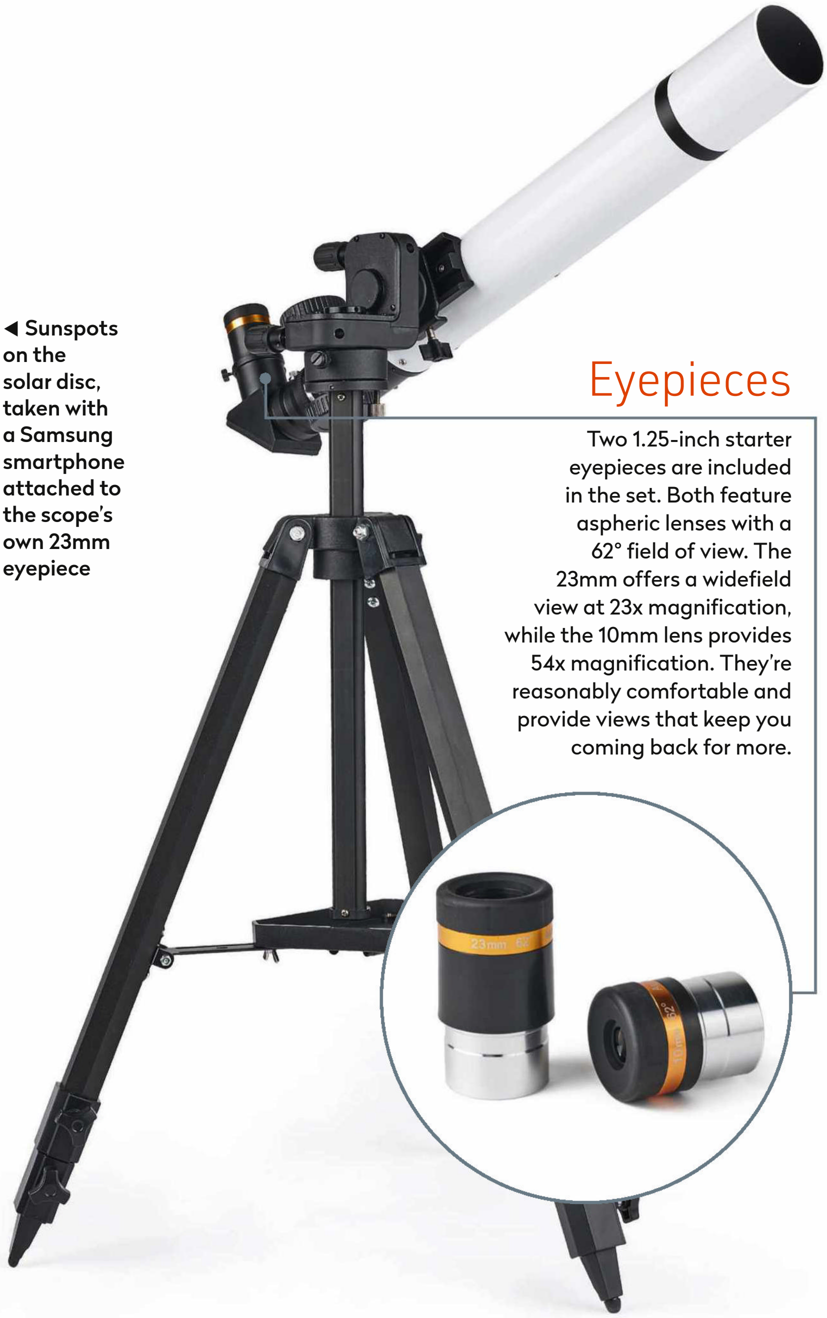
The mount head is eased into position by two simple control knobs. The altitude adjuster is quite close to the telescope, which may prove slightly awkward for those with large hands. It moves the telescope if turned quickly, but is responsive enough to allow slow and deliberate tweaks too.

FIRST LIGHT



◀ Sunspots on the solar disc, taken with a Samsung smartphone attached to the scope's own 23mm eyepiece

Our daylight high-contrast lens test, taken with a smartphone and our own 25mm Plössl, showed excellent colour control



Eyepieces

Two 1.25-inch starter eyepieces are included in the set. Both feature aspheric lenses with a 62° field of view. The 23mm offers a widefield view at 23x magnification, while the 10mm lens provides 54x magnification. They're reasonably comfortable and provide views that keep you coming back for more.

▶ with a simple telescope on a basic mount. Before there were Go-To mounts, before 'accessible astrophotography' was a thing and long before smart telescopes, a simple refractor like the Sightron Infini D50 was the tool that first nurtured our love of backyard astronomy.

As the stars gradually emerged, we found ourselves falling in love with star-hopping again. The hunt, and the reward that follows, has always been part of the thrill, and as we waited a couple of seconds for the vibrations to settle before eagerly scouring the view of our target, we found ourselves smiling. The refractor has no mirrors to collimate, there's no polar alignment to perform and no complicated app or handset to operate.

Along with open star clusters and beautiful coloured double stars like Albireo, we also tried to track down Messier list targets: the globular cluster in Hercules, M13, the Ring Nebula, M57, and the Dumbbell Nebula, M27. The rudimentary finder on the Sightron meant placing these objects in the centre of the eyepiece proved a challenge, but the extended chase only served to enhance the thrill of the victory. Any foibles of the mount were far outweighed by the sense of achievement as we toured the skies. If it isn't clear by now, we thoroughly enjoyed using this little achromat!

The Sightron Infini D50 may just be the perfect telescope for discovering, or rediscovering, a love for pure and simple astronomy. Its hands-on simplicity reconnects you, in a deeply personal way, with the night sky's wonders. With rewarding views at a modest price, the only upgrade we'd suggest is popping it on a different tripod.

VERDICT

Assembly	★★★★☆
Build & design	★★★☆☆
Ease of use	★★★★☆
Features	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. Ursa Major 7mm–21mm FMC zoom eyepiece

2. Starfield 1.25-inch Herschel solar wedge

3. Astro Essentials 6x30 illuminated finderscope

©THESHED_PHOTOSTUDIO X 2, TIM JARDINE X 2

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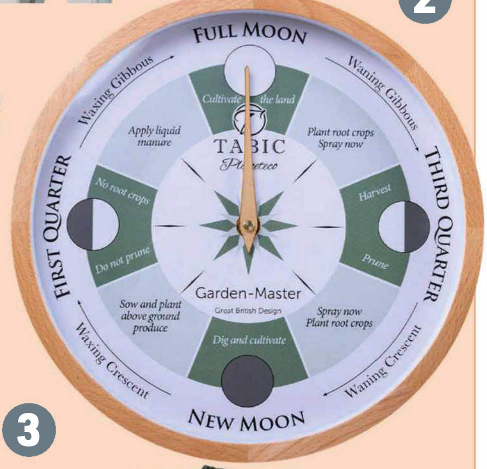
Charlotte Daniels rounds up the latest astronomical accessories

GEAR

1


2

FULL MOON
Waning Gibbous
THIRD QUARTER
Waning Crescent
NEW MOON
Waxing Crescent
FIRST QUARTER
Waxing Gibbous
TABIC
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Cultivate the land
Plant root crops Spray now
Harvest
Prune
Spray now Plant root crops
Dig and cultivate
Sow and plant above ground produce
Do not prune
No root crops
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3

NASA
UNITED STATES
CASE TRAINING, ROCKET SCIENCE
TYPE RS2
SPEC No 42-20074-P

4

5

FLO
FIRST LIGHT OPTICS
DEEP SKY
IMAGING EXPERIENCE
GIFT VOUCHER

6

STAR ANALYSER 200-F

1 Astro Essentials smart telescope wedge and tripod kit

Price £89 • **Supplier** Harrison Telescopes
www.harrisontelescopes.co.uk
Based on Sky-Watcher's AZ3 platform, this custom mount has been adapted for any smart telescope with 3/8-inch threads and includes a tray for accessories. With a payload capacity of 5kg and maximum tripod extension of 120cm, the altazimuth controls aid polar alignment for imaging perfection.

2 Moon phase garden clock

Price £79.95 • **Supplier** Tabic
www.tabic.co.uk
This garden clock could be the perfect accessory for green-fingered astronomers. Made from beech wood, it tracks the Moon's phases and advises the best time to plant, spray and care for your harvest. It measures 30cm x 5cm and is available in natural or dark stain.

3 NASA backpack

Price £85 • **Supplier** Flightstore
www.flightstore.co.uk
This distinctive backpack looks like it could have come straight from an astronaut training academy! Made from nylon, it features NASA patches, side pockets and a front pouch for essentials. This could make a lovely schoolbag for aspiring spacefarers.

4 Merino fingerless gloves

Price £15 • **Supplier** Sealskinz
www.sealskinz.com
These lightweight wool gloves will keep your hands warm as the nights get colder, leaving fingertips free to tinker with your telescope or mount controls. Available in a range of colours.

5 Deep-sky imaging experience gift voucher

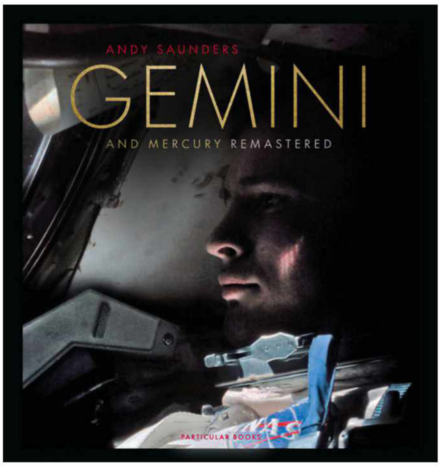
Price £199 • **Supplier** First Light Optics
www.firstlightoptics.com
Even in the middle of winter, temperamental skies mean that astrophotography opportunities are hit and miss. Treat someone special to a remote observatory experience using First Light Optics' southern Spain facilities. Valid for six months after purchase.

6 Star Analyser 200

Price £133.06 • **Supplier** Paton Hawksley
www.patonhawksley.com
Discover the night sky with this 1.25-inch diffraction grating. Specially designed for DSLR cameras and long-focal-length telescopes, this filter is an instant step into the world of amateur spectroscopy, as you unveil the chemical composition of stars.

New astronomy and space titles reviewed

BOOKS



Gemini and Mercury Remastered

Andy Saunders
Particular Books
£50 ● HB

When released in 2022, Andy Saunders' *Apollo Remastered* offered a transformative new view of the Moon landings. Carefully curating Apollo's enormous photographic archive, his image processing brought the missions to life as never before. In this prequel, Saunders revisits the cold storage vaults at NASA's Houston Space Center to process rare imagery from the earliest days of the US crewed space programme.

Gemini and Mercury Remastered takes us to the heyday of the Space Race, when the United States was playing catch-up with the Soviets' early Sputnik and Vostok launches. Basic though they were, the suborbital hops and orbital flights of the Mercury programme (1961–63) provided NASA with a vital foothold in space. The more sophisticated Gemini flights (1965–66) then drew level with and overtook the Soviet lead in the race to the Moon.

As the preface explains, photography was something of an afterthought during Mercury planning. While film cameras were trained on pilot and instruments, still photography was largely driven by the enthusiasm of individual astronauts like John Glenn and Gordon Cooper. The surprising details they revealed, particularly in images of Earth from orbit, led mission planners to recognise the potential of space photography, paving the way for the more extensive Gemini photographic archive.

These stunning images transport the viewer to key moments in early US spaceflight, from Ed White's spectacular Gemini 4 spacewalk to the orbital rendezvous of Geminis 6A and 7, and Gemini 8's first docking in space. The pictures mix the familiar and previously overlooked, while some are, in effect, entirely new: Saunders mixes restorations from the original 70mm negatives with fresh 'stills' created by overlaying multiple frames of 16mm movie film. There's an introduction for each mission, while detailed captions describe the action moment by moment. The book closes with accounts of the equipment and processes used during the missions, and in this remastering project. Yet it's the images themselves that remain the star of the show. This is an essential addition to the library of every spaceflight enthusiast. ★★★★★

Ed White's spacewalk: Saunders transports you to key moments in US spaceflight before Apollo

NASA

***Giles Sparrow** is a science writer and author*

Interview with the author
Andy Saunders

Why were Gemini and Mercury so special?

For millennia, we'd dreamt of flying to the stars, and this was when that became reality. We could look back at Earth for the first time. Mercury – one-man missions in tiny capsules – proved we could get a human into space and back. Then Kennedy set the goal of landing on the Moon, and it was down to Gemini to show this was possible. With two-man capsules, Gemini tested rendezvous, docking, spacewalking and long-duration flight – all still fundamental today.

How did you approach the restoration?

Scans of the originals were thought too important to handle, so NASA created copies and sealed away the originals. Now NASA has digitised the original film, so we're working with raw light captured from spacecraft over 60 years ago. I also worked with 16mm motion picture film. It's low resolution, so I used a technique akin to image stacking. It's painstaking, but the payoff is seeing these pivotal images as never before.

Are you looking forward to seeing the Artemis images?

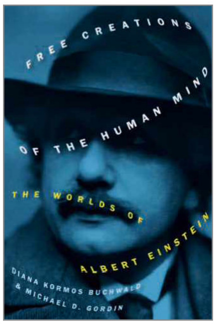
I can't wait. Having spent time with the Artemis II crew, I know they're aware of the importance of photography. The landings will be live-streamed, there will be 360° views and helmet cams. Are we desensitised to it? Photographs are now transient, enjoyed for a second then gone with the swipe of a finger. Artemis imagery will be incredible, but whether it can match the romance of early space exploration on film remains to be seen.

***Andy Saunders** is a film restorer who specialises in NASA imagery*

SCIENCE HISTORY

Free Creations of the Human Mind

Diana Kormos Buchwald and
Michael D Gordin
Oxford University Press
£14.99 ● HB


FREE CREATIONS OF THE HUMAN MIND
THE WORLDS OF ALBERT EINSTEIN
DIANA KORMOS BUCHWALD & MICHAEL D. GORDIN

Albert Einstein continues to fascinate and inspire us, 70 years after his death. The boy who showed little early promise in academic studies would go on to formulate one of the most successful physical theories of modern science, and kick-start another. His legacy is unmatched, though his complex character is unfortunately shrouded by what the authors of *Free Creations* call a 'popular iconography'.

This short book seeks to dispel some of the biggest myths. One of the most interesting is Einstein's dispute with Niels Bohr during the 1920s and 1930s concerning the interpretation of quantum mechanics. Apparently, the 'argument' was much less public and vociferous than depicted elsewhere. It may have been the affront of other players, among them Wolfgang Pauli, that exacerbated the dispute in the minds of both professionals and the public. *Free Creations* provides us with an insightful chronology of the broad differences of opinion at the dawn of quantum theory, and Einstein comes off much less obstreperous than he has hitherto been portrayed.

In August 1939, Einstein wrote to President Franklin D Roosevelt with a warning that German scientists may soon have the capacity for "extremely powerful bombs". This communication, arguably Einstein's most famous, essentially led to the establishment of the Manhattan Project, which ultimately led to the deaths of hundreds of thousands of Japanese citizens. How this squared with Einstein's declared pacifism, and how he viewed these dangerous developments, are neatly summarised here. Again, public perception may have clouded the facts.

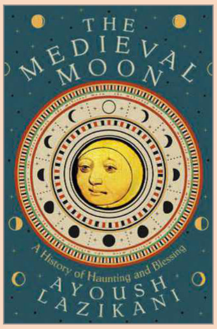
Other aspects of the man ably dealt with are his nationalism (or lack thereof), pacifism and anti-Zionism. Although it's well documented that he was against the establishment of a Jewish state, and regarded himself as an agnostic whose religious beliefs were merely of a moral kind, the book provides a succinct and illuminating commentary.

There are almost innumerable biographies of Einstein, cataloguing his scientific insights, his political views, his personal life and how these combined to give us the popular icon so familiar to us all. *Free Creations* offers something different. The authors carefully pick apart Einstein's persona, respectfully and evidentially, and reassemble him in the context of his times. This lucid and insightful portrait of the great man is a welcome addition to bookshelves everywhere. ★★★★☆

***Alastair Gunn** is a radio astronomer and science writer*

The Medieval Moon: A History of Haunting and Blessing

Ayoush Lazikani
Yale University Press
£20 ● HB



How did people view the Moon a thousand years ago? That thought-provoking question is the central premise of this curious book about the 'medieval Moon'.

However, this is not an astronomical take on the Moon: astronomers, and even astrologers, did not (and indeed do not) have exclusive rights over how to interpret and study Earth's natural satellite. Rather, *The Medieval Moon: A History of Haunting and Blessing* takes us on a dreamy journey through a plethora of different stories, myths and uses of the Moon across a variety of cultures and eras.

The book introduces us to religious, artistic, poetic and medical approaches to the Moon, showing just how important our closest neighbour was to people across the world a millennium ago. While many Moon books focus on how to view it, what to see and how to understand those observations astronomically, this one offers something different.

Taking what Ayoush Lazikani terms a "multi-glance" perspective, it considers stories of the Moon from across the world and throughout history. These include an old Norse riddle, where Thor asks "What is the Moon?", and the Chinese tale of Chang'e, the goddess who travelled to the Moon. We see how our lunar neighbour was used as a means of setting the mood and foreshadowing a change of fate in works by, among others, Chaucer and Al-Shushtari. We learn about moonbooks (medieval texts that used lunar imagery to guide spiritual reflection) and anchorites (recluses who lived in cells attached to churches and used the Moon as a symbol of divine presence), and about the connections medieval people made between the Moon and their physical and mental health. We learn too about lunar prophecies. While its phases made the Moon seem inconsistent, its gentle light on dark nights offered comfort.

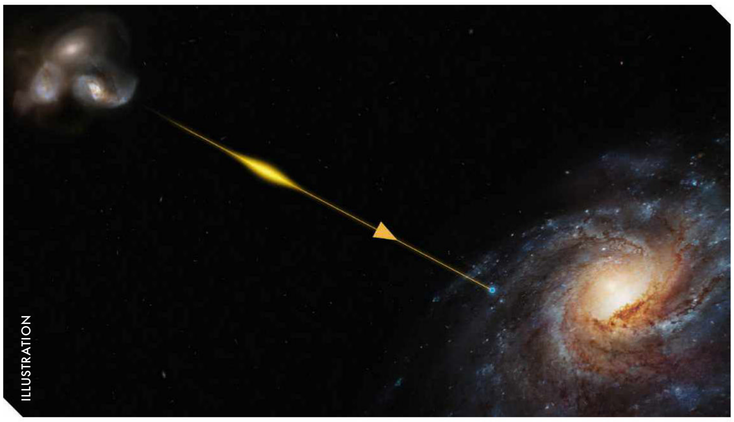
The Medieval Moon is full of interesting stories and makes a fascinating introduction to medieval thought for readers like me who have very little knowledge of the period. It's not, however, an exhaustive chronicle: some cultures' lunar calendars are mentioned, others are not; and some traditions feature more heavily than others. But that's not the book's aim; rather, it offers a thoughtful step away from viewing the Moon as solely the domain of the astronomer. We learn the Moon – as fact, as metaphor, as symbol – is for everyone.
★★★★☆

***Emily Winterburn** is a science historian and writer*

Anita Chandran talks to Professor Liam Connor

Q&A WITH A FAST RADIO BURST EXPERT

A significant amount of the Universe's matter from the Big Bang is missing. Now scientists believe they've found it hiding between galaxies



▲ **Fast radio bursts (FRBs), powerful radio signals from across the Universe, pointed the way to the 'lost' matter**

ESO, M. KORNMESSER

What is normal or 'ordinary' matter?
When astronomers talk about normal matter, we're referring to baryons. By that, we just mean 'the stuff of atoms' – things like protons and neutrons.

How did we find out some of the Universe's ordinary matter was missing?
We can see leftover light from the Big Bang; we call this the cosmic microwave background radiation or CMB. Fluctuations in the CMB give us a snapshot of how things were around 400,000 years after the Big Bang – a kind of 'baby photo' for the Universe, which tells us how much matter there was, both normal and dark. All those atoms should still be here 13.8 billion years later. But, if you count the stars and planets and dust you can see with your telescope, you'll find a significant amount of matter appears to be missing.

Where did you find this missing matter?
Hiding! It turns out that most of the matter in the Universe is well outside of the haloes of galaxies. It's a kind of wispy, diffuse state that we call the intergalactic medium. If you zoomed out on an image of the Universe and kind of blurred your eyes, the intergalactic medium would look like a fuzzy cosmic web. We used objects called fast radio bursts to help us find this matter.

What is a fast radio burst?
Fast radio bursts, or FRBs, are pulses of radio waves. They usually last around a millisecond, but can be as short as 10 microseconds – so they're very fast. They were discovered in 2007, so a relatively 'new' cosmic phenomenon. In the last decade, we've shown that FRBs are coming from billions of lightyears away.

How did you use FRBs to work out that there was so much missing matter?
The order of operations is like this. You see a little blip with a radio telescope, and you can pinpoint where it is on the sky and which galaxy it could be coming from. You then use an optical telescope to follow it up, which gives you a fingerprint of the galaxy; it tells what type of galaxy hosts the FRB, and also how far away it is. This tells us how much the radio waves were slowed down by intervening matter, which depends on the density of matter it interacts with. By doing this, we can work out the average density of normal matter in the Universe. A sample of, say, 50 or 100 FRBs tells you a lot about where the missing matter is hiding.

Liam Connor is an assistant professor of astronomy at Harvard University, researching fast radio bursts and AI in astrophysics, and building large radio telescope arrays

What do you think could be causing FRBs?
There's no consensus yet. Many people would say neutron stars, which are what's left behind when a very large star explodes and the remaining matter isn't quite massive enough to form a black hole. We think FRBs could come from a type of neutron star, which are relatively young and highly magnetised. Whatever their origin, the fact that you can observe these radio bursts billions of lightyears away means that their source must be extremely luminous; there aren't many candidates for that type of object.

What are the implications of your discovery?
In my view, the most interesting aspect of our research paper is not that we found the missing ordinary matter, but that this matter was contained outside of galaxy haloes. When galaxies form, they slosh matter around in a process called feedback. Our results suggest that there is a strong and efficient feedback process that sort of smooths out the matter in the Universe.

What's next for your team?
On some level, the fun really begins now. For many years, we didn't know the large-scale distribution of normal matter in the Universe. We couldn't even find it. Now, there are a host of unanswered questions that we can explore, like what is the distribution of gas in the Universe and how does that relate to the growth of supermassive black holes?

It also has a huge impact on precision cosmology. For upcoming telescopes and projects like the Nancy Grace Roman or Euclid space telescopes, knowing where ordinary matter is can reduce systematic errors and enable us to more meaningfully interpret the data we record.

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Spot horizon-hugging Mars and Mercury together after sunset, then cruise down a starry river

When to use this chart

1 Oct 00:00 AEST (30 Sep, 14:00 UT)
15 Oct 23:00 AEDT (12:00 UT)
31 Oct 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

OCTOBER HIGHLIGHTS

Elusive Mercury makes a favourable but brief return to the early evening sky. Rising in the west-southwest early in the month, it passes Mars as they head towards conjunction; their closest approach (1.9°) is on 19th. During this time, Mercury is noticeably brighter than Mars. These planets and a thin Moon form an attractive isosceles triangle on 23rd, fitting in a 5° circle – a great binocular view! It's best to look around an hour after sunset. A clear horizon is a must.

STARS AND CONSTELLATIONS

As the Milky Way drops into the west, the far southern heavens take centre stage. Dark skies are needed to see two satellite galaxies of our own: the Magellanic Clouds. Just north of the small cloud (SMC) lies isolated Achernar (Arabic for 'river's end'), the alpha star to Eridanus, the River, and the ninth-brightest star in the night sky. Follow Eridanus through the evening as its long line of faint fourth-magnitude stars meanders across the sky, finally reaching its headwater near Orion.

THE PLANETS

Mars, low in the west, sets around 30 minutes after the end of twilight. The Red Planet is joined briefly by Mercury. Saturn is well placed to observe, transiting mid-evening. More distant Neptune closely follows this ringed world 30 minutes or so later. Turning to the morning, Jupiter is rising around 01:00 mid-month and best to view around the start of dawn. Midmorning finds Uranus transiting and, finally, as the night closes, a very challenging Venus rises in the eastern dawn sky.

DEEP-SKY OBJECTS

This month, a trip to the deep south and Tucana, the Toucan. Kappa (κ) Tucanae (RA 1h 15.7m, dec. –68° 53') is a brilliant double star comprising mag. +5 yellow and mag +7.5 yellow/orange components, 5 arcseconds apart. Kappa also makes a great binocular double with an eighth-magnitude companion lying 5 arcminutes to the northwest.

Tucana is home to the impressive star cluster '47 Tuc', but don't overlook its other globular, NGC 362 (RA 1h 3.2m, dec. –70° 51'). Located 2° south-southwest of Kappa, on the northern edge of the Small Magellanic Cloud (47 Tucanae is on the western side), this seventh-magnitude globular has a vivid 5-arcminute dense core, easily visible in binoculars. The cluster's brightness suddenly drops as you enter the surrounding 12-arcminute-diameter halo. NGC 362 is resolvable in 150mm–200mm telescopes.

Chart key

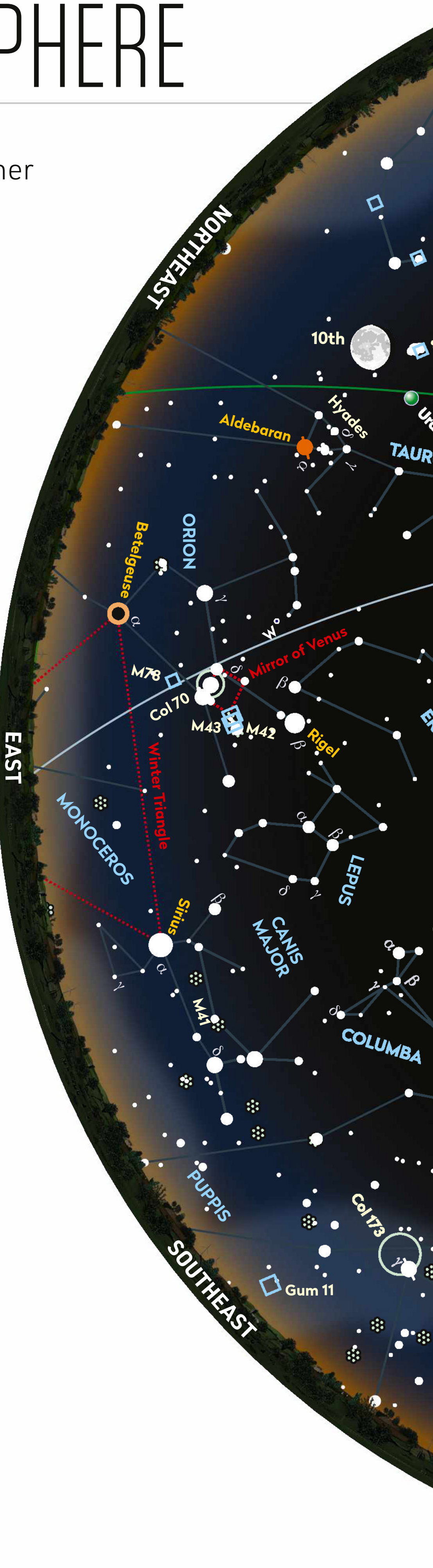
⬭ GALAXY
◌ ⁘ OPEN CLUSTER
⊕ GLOBULAR CLUSTER
☼ PLANETARY NEBULA

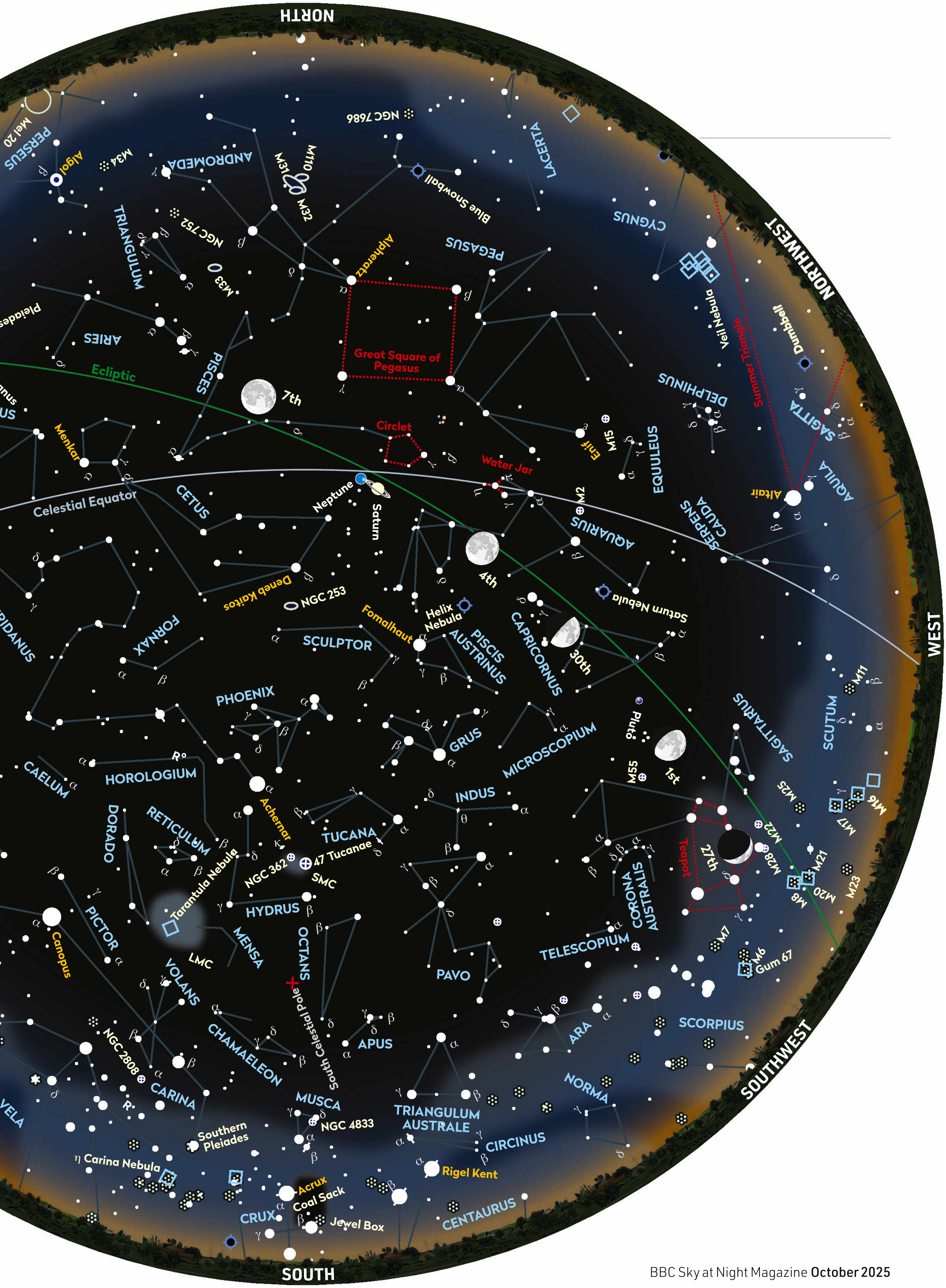
□ DIFFUSE NEBULOSITY
● DOUBLE STAR
○ VARIABLE STAR
☄ COMMET TRACK

ASTEROID TRACK
△ METEOR RADIANT
☼ QUASAR
🪐 PLANET

STAR BRIGHTNESS:
● MAG. 0 & BRIGHTER
● MAG. +1
• MAG. +2
• MAG. +3
· MAG. +4 & FAINTER

CHART: PETE LAWRENCE




NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Mel 20
PERSEUS
Algol
M34
ANDROMEDA
M31
M110
M32
NGC 7686
Blue Snowball
LACERTA
CYGNUS
TRIANGULUM
NGC 752
M33
Alpheratz
PEGASUS
Veil Nebula
Dumbbell
Summer Triangle
Pleiades
ARIES
PISCES
Great Square of Pegasus
Ecliptic
7th
DELPHINUS
SAGITTA
Menkar
Circlet
Water Jar
Enif
M15
EQUULEUS
AQUILA
Altair
Celestial Equator
CETUS
Neptune
Saturn
M2
AQUARIUS
SERPENS CAUDA
4th
Deneb Kaitos
NGC 253
Fomalhaut
Helix Nebula
Saturn Nebula
ERIDANUS
FORNAX
SCULPTOR
PISCIS AUSTRINUS
CAPRICORNUS
30th
M11
SCUTUM
PHOENIX
GRUS
Pluto
SAGITTARIUS
MICROSCOPIUM
1st
M55
M25
M16
M17
CAELUM
HOROLOGIUM
INDUS
Achernar
DORADO
RETICULUM
TUCANA
47 Tucanae
NGC 362
SMC
Teapot
27th
M22
M28
M21
M8
M20
M23
Tarantula Nebula
HYDRUS
CORONA AUSTRALIS
PICTOR
Canopus
LMC
MENSA
OCTANS
TELESCOPIUM
M7
M6
Gum 67
PAVO
VOLANS
South Celestial Pole
ARA
SCORPIUS
NGC 2808
CHAMAELEON
APUS
CARINA
NORMA
VELA
MUSCA
NGC 4833
TRIANGULUM AUSTRALE
Southern Pleiades
CIRCINUS
η Carina Nebula
Rigel Kent
Acrux
Coal Sack
Jewel Box
CRUX
CENTAURUS